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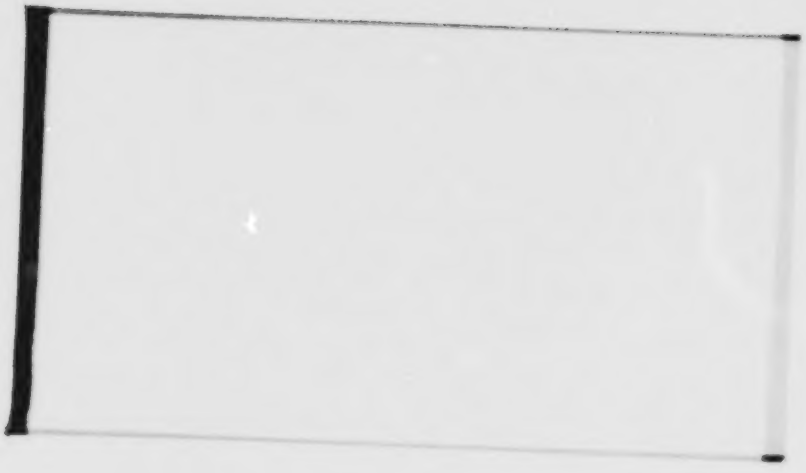

May 1985

EVALUATION OF THE INTEGRATION OF THE SANDWELL CENTRAX$_{TM}$ PROCESS INTO AN INTEGRATED TWO-STAGE LIQUEFACTION PROCESS

PHASE II - (Equipment Development)

FINAL REPORT

by

Sandwell Technologies

Work on this project was conducted under the auspices of the Canada Centre for Mineral and Energy Technology, Energy, Mines and Resources Canada.

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MICROMEDIA

Sandwell Technologies

SUMMARY

Sandwell Technologies, formerly Sandwell Beak Research Group, a Division of Sandwell and Company Limited, has developed a process for the deashing of coal liquids. The Sandwell Centrax™ Process* is an advanced approach to the complete recovery of liquid hydrocarbons from solids such as coal mineral matter and unconverted coal.

The Centrax Process uses a specially selected process-derived solvent to keep both distillable and non-distillable oils in solution while positively removing solids using centrifugal force. The resultant solids cake can be subsequently re-mixed with extractant and separated until the interstitial liquids in the solids phase can be removed by evaporation, rendering a dry friable solids cake.

The execution of these process steps requires special mechanical equipment having features and capabilities unavailable in existing centrifugal separators. Further development of the Centrax Process required the development of hardware specially designed to perform the Centrax deashing steps in an efficient reliable manner.

* Centrax is a trade mark for Sandwell and Company Limited.

SOMMAIRE

Sandwell Technologies, auparavant appelé Sandwell Beak Research Group, une division de la Compagnie Sandwell Limité, a développé un procédé pour l'enlèvement de la cendre présente dans les produits de la liquefaction du charbon. Le procédé Centrax™ est une approche avancée vers la séparation et la recupération complete de hydrocarbures liquides par rapport aux solides comme par exemple mineraux et charbon nonconvertit.

Le procédé Centrax utilise comme solvent une fraction du produit spécialement sélectionnée afin de garder en solution touts les huiles-distillables de même que nondistillables et en même temps enlèvant les solides a l'aide d'une force centrifuge. Les solides séparés de cette maniere peuvent être remélanges avec l'extractant dans une étape subséquente pour être séparés jusqu'au moment quand touts les liquides interstitiels présentes dans la phase solide sont constitués des distillables qui peuvent être récoupéres par évaporation tout en rendrant les solides dans une croute friable est seche.

L'exécution des cettes étapes du procédé demande une pièce d'équipement mécanique spécial avec de caractéristiques qui ne sont pas disponsibles dans les séparateurs centrifugaux existentes. Les traveaux de développement du Procédé Centrax ont demandé le développement d'un séparateur spécialement affecté pour accomplir d'une manniere sure et efficace les étapes de enlèvement des cendres.

As a result of this need to combine hardware as well as process concepts in Centrax Technology, Sandwell with the support of the shared-cost coal conversion program of the Canada Centre for Mineral and Energy Technology (CANMET), has proceeded with the development of a prototype Centrax Separator. This report outlines the development of the prototype separator through the conceptual design phase through to an assembled unit, ready for further development and demonstration of both hardware and process aspects of Centrax Deashing.

Sandwell a du combiner les efforts pour le développement simultané d'un dispositif tout a fait spécial avec le développement des concepts de la Technologie Centrax. Avec le support du Centre Canadien de la Technologie des Mineraux et de l'Energie, le programme au frais-partages, Sandwell a entreprit le dessein et construction du premier Séparateur Centrax. Ce rapport decrit le travail pour le développement du prototype a partir du dessein conceptuel jusqua la réalisation de l'unite assemblée, prête pour demonstrer autant le fonctionemment de l'appareil que les aspects du procéssus Centrax

The design of the Centrax unit was directed by Dr. P.G. Groeneweg of Sandwell Technologies. Numerous Canadian companies and suppliers were engaged to provide services and parts for the Separator is an innovative device with many special features essential to the commercialization of the Centrax Deashing Process.

Le travail de dessein du prototype a ête supervisé part Dr. P.G. Groeneweg de Sandwell Technologies. Des nombreux compagnies et fourniseurs ont ête engagés pour fournir des services et pièces pour le développement du prototype. Le séparateur Centrax est un dispositif avec plusieurs charactéristiques spéciales qui sont essentieles pour la commercialisation du Procédé d'Enlèvement des Cendre Centrax.

The following summarizes the special features of the Centrax unit which distinguishes it over other centrifugal devices for this purpose:

- operation at relatively high temperatures,
- separation of operating environment and drive mechanism,
- independent control of liquid and solids residence times to allow for performance optimization of slurries with different separation characteristics,
- capability of discharging the solids directly into a transfer extraction medium to provide a mechanical means of high intensity inter-stage mixing

Le suivant est le sommaire des charactéristiques distinctifs de l'unite Centrax qui ne sont pas trouvées dans d'autres séparateurs centrifugaux utilisés pour des buts similaires:

- opération a des températures relativement élevées,
- le moteur et le mécanism de transmission sont séparés du milieu d'opération,
- les temps de résidence du liquid et des solides sont indépendement controlés pour permetre l'optimisation de la performance de séparation pour des matériaux avec des propriétés différentes,
- les solides sont déchargés

with minimal solids handling between separation stages.
- capability of handling solids with a wide range of physical characteristics.

The Centrax Separator is expected to be an exceptional device for deashing hydrocarbons and recovering hydrocarbon liquids.

The next report in this series will include the results of the work related to the commissioning, on-going development and the operation of the unit with coal liquids from an integrated two-stage liquefaction process.

diréctement dans le milieu d'extraction qui sers aussi comme milieu de transfér et fournit les moyens méchaniques pour une intense agitation entre les étapes de séparation avec manipulation minime des solides,
- l'appareil peut traiter une large variété des solides ayant des propriétés différentes.

Le Séparateur Centrax est un dispositif d'une efficacite exceptionnele pour la recupération des hydrocarbures liquides et pour l'enlèvement de cendre.

Le prochain raport dans cette serie comprendra les resultats du travail de mis en marche, les dévelopements ulterieures et une description de l'opération du séparateur avec des liquides provenus d'un processus à deux étapes intégrées.

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APPENDICES - 1. Conceptual Design Report
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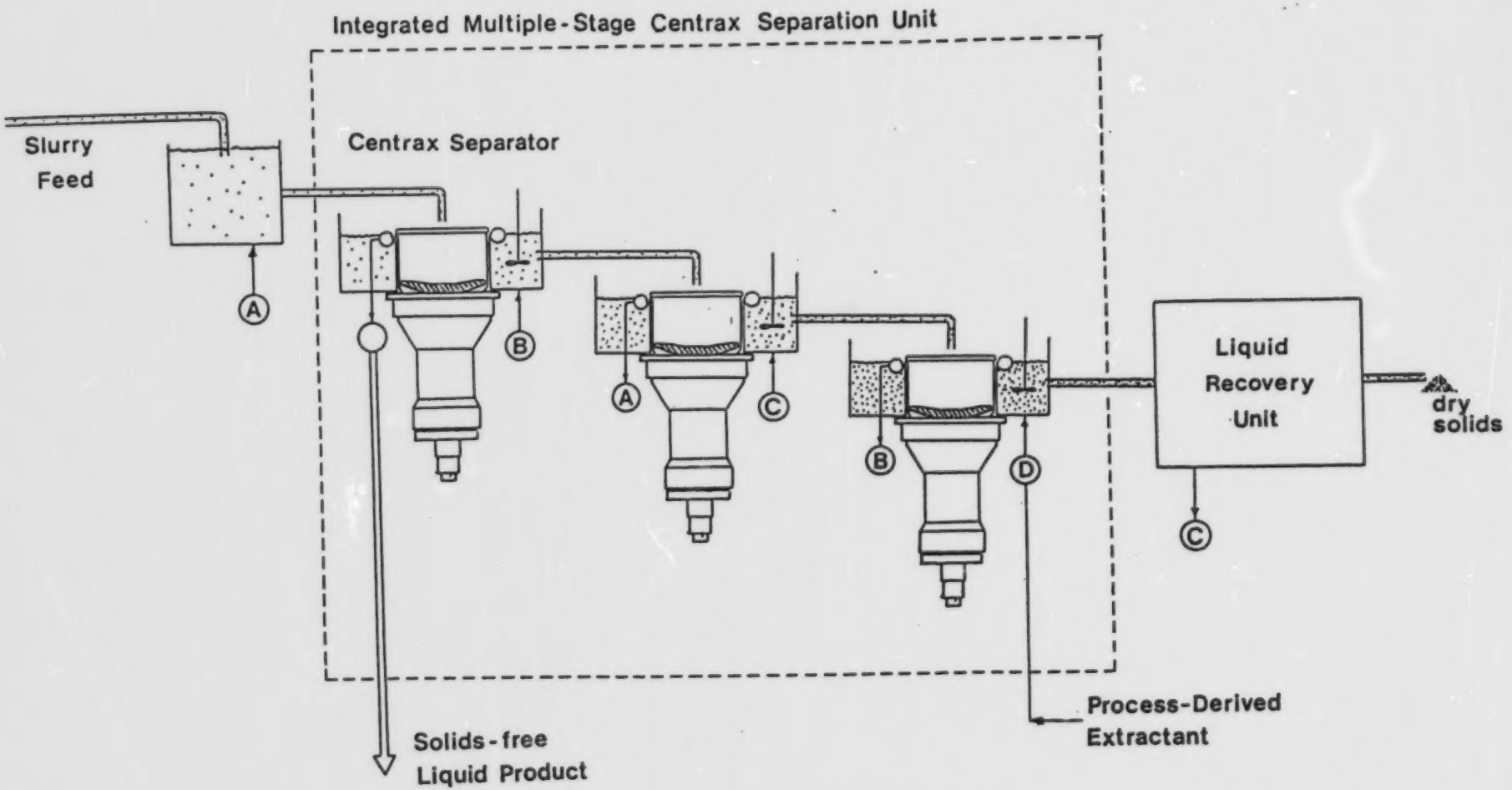
3. Final Development Report

Figure 1. CENTRAX DEASHING PROCESS – 3 Stage Counter-current Arrangement



Photograph 1. Prototype # 1 Centrax Separator
Single stage, multi-functional unit

1.0 INTRODUCTION

As lower grade resources - coal and bitumen - are turned to as a source of premium transportation fuels, the efficient deashing of hydrocarbon products will be an important step in the hydroprocessing of these materials. Sandwell and Company Limited, through Sandwell Technologies has developed an advanced process which achieves complete liquid product recovery and liquid-free solids. The Sandwell Centrax process extracts liquid products from solids using a process-derived extractant in specially configured stages. The Process uses positive separation forces generated by centrifugal action to separate liquid and solid phases.

Although centrifuges have been employed in separating coal liquids, their function has mainly been to remove solids from liquids rather than the complete recovery of liquid products. As well, numerous technical difficulties were encountered related to the abrasive and viscous nature of coal liquefaction sluries. The use of anti-solvents aiding in achieving clear centrates, produces slurries concentrated in both solids and pre-asphaltenes, a combination that results in a material which is difficult to handle or transport.

With the Centrax technology, asphaltenes and pre-asphaltenes are separated from the solids so that the concentrated solid stream becomes easier to handle through multiple extraction stages. The processing requirements of the Centrax Process, give rise to the need for a mechanical centrifugal separator having unique features and capabilities unavailable in any existing equipment. Figure 1 illustrates the function of the Centrax Separator in a multiple stage Centrax Deashing arrangement.

With the support of the CANMET shared-cost conversion program, Sandwell has undertaken to design a piece of equipment which has the key mechanical features required to satisfy the Centrax process requirements. This document describes the special mechanical requirements of the Centrax Separator and outlines the design development of an innovative centrifugal separator system which has been fabricated and successfully operated. The unit is located at Sandwell Technologies' offices and laboratories at 6870 Goreway Drive, Mississauga, Ontario where commissioning and operation continues. The photograph of the assembled prototype Centrax Separator on the next page illustrates the complete multi-functional unit designed and fabricated during this study for the purpose of further development and demonstration of Centrax Deashing Technology.

2.0 DEVELOPMENT OF DESIGN SPECIFICATIONS

The Centrax Separator development has been based on the objective of meeting certain performance requirements, taking into account the nature and quality of the materials to be separated. Specifications were established for the Centrax prototype with the following main criteria:

- o physical properties of the materials to be processed
- o operating conditions
- o mechanical requirements
- o type of apparatus

The rationale for the specific criteria used in the prototype design is discussed under these headings in this section.

2.1 Physical Properties of Processed Materials

The development of the Centrax Separator started with an appreciation of the nature and characteristics of the slurry stream to be separated, as well as final product streams. This knowledge had been gained through extensive bench-scale testing with coal liquids which led to an understanding of the extreme difficulty in separating fine coal ash and unconverted coal from intermediate coal liquids rich in asphaltenes and pre-asphaltenes. This difficulty is derived from both the nature of the solids and the physical properties of the liquids. To the extent that these properties can be quantified, they are discussed below.

Solids Concentration

The solids concentration for coal liquefaction products varies over a wide range, typically from 5 - 20% on a weight basis, generally reflecting the solids loading in coal liquids after primary liquefaction. Should the lower boiling distillates be removed prior to Centrax Separation, the solids concentration would be at the higher end of the range.

Particle Size

It is expected that the particles will be in the range of 0.1 to 100 microns. The addition of anti-solvents has been shown to precipitate pre-asphaltenes which aids in the agglomeration of these fine particles, enhancing their separability under gravitation force. However, this results in the inability to recover all the liquids free of solids and thus represents a considerable compromise. The objective of the Centrax Process is to separate the solids without precipitation of asphaltenes

and pre-asphaltenes. This requires the solids to be separated under high G forces.

Particle Density

The density of the solids are variable, and indicative of their composition. The most dense particles are the coal mineral matter ($\sim$2.5 g/cm^3) and the least dense and most difficult to separate, are the unconverted coal particles ($\sim$1.3 g/cm^3).

The small particle size, combined with the low density driving force gives these particles a very low settling velocity.

Solution Density

The density of the solution will be dependent on the composition of the solution with respect to the relative proportions of light, heavy and non-distillate fractions. Typical solution densities are expected to be in the range of 0.9 to 1.1 g/cm^3.

Viscosity of the Liquid Phase

The viscosity of the liquid phase has not been specifically tested. However, the liquids are solid or very viscous at ambient temperatures and require processing at elevated temperatures where the mixtures are fluid. The solidification of the material due to cooling must be avoided throughout the processing steps.

Composition of the Solids Phase

The solids phase is a mixture of coal particles and coal mineral matter. The coal particles are likely the very refractory macerals found in most coals that cannot be dissolved in process-derived liquefaction solvents.

Composition of the Liquid Phase

The liquid phase consists of a combination of coal-derived liquid hydrocarbons ranging from very light distillates (low molecular weight) to very heavy and non-distillate fractions (very high molecular weight). These latter materials are often known as asphaltenes and pre-asphaltenes.

Characteristics of "Wet" Solids

The "wet" solids from the initial separation stage are very abrasive, sticky and non-flowable. Although concentrated in solids, the interstitial spaces are still occupied by liquid hydrocarbons including asphaltenes and pre-asphaltenes at the end of the first separation stage. This contributes to the sticky nature of the solids.

Characteristics of the "Dry" Solids

The "dry" solids, although still abrasive, become non-sticky and flowable as a result of the recovery of the liquid hydrocarbons from the interstitial spaces. The final liquid recovery step is not included in the Phase II - equipment development, and thus, dry solids are not produced or experienced within the mechanical Centrax Separator. However, the "wet" solids are changed to the extent that the characteristics of the interstitial liquids becomes progressively less concentrated in the heavier hydrocarbons.

Filterability of Solids Cake

The solids cake has very poor filtration characteristics.

2.2 Operating Conditions

The nature of the solids and liquids dictate the operating conditions required for effective separation in the Centrax Separator.

Temperature

As a result of the large temperature effect on viscosity, the equipment must be able to operate at temperatures up to 200°C.

Pressure

One advantage of the Centrax Process is that the process steps can be performed at atmospheric pressure. This simplifies the mechanical design requirements.

Residence Time

Short residence times are desired to keep equipment costs down. It is desired to have residence times in the order of 3 - 10 seconds in each stage.

Centrifugal Force

In order to provide a strong positive separation, a centrifugal force in the order of 3000 G is required.

Hydraulic Capacity

Preferably, the prototype unit should operate at reasonably high throughput rates, although this will be related to size of the prototype. Nominally, slurry feed rates of 0.5 - 4 USGPM (100-800 1/h) were considered to be approprate size for the initial prototype.

Solids Throughput Capacity

The unit is based on the above hydraulic loading capacity must be capable of handling solids at the rate of 15 - 400 Kg/h.

Centrate Clarity

An objective of 0.01% solids on a weight basis for the centrate was identified to represent a very high level of separation performance.

2.3 Mechanical Requirements

Due to the abrasive nature of the slurries to be processed, the Centrax Separator must have mechanical features to achieve reliable continuous operation. These have been identified as follows:

Fabrication

The potential for exposure of bearings and seals to the abrasive slurry should be minimized. Simplicity in design dictates a minimum number of parts, which can be purchased from existing suppliers or readily machined with a minimum of complexity.

Maintenance

Ease of maintenance is essential for both research prototypes and eventually, commercial units.

Accumulation of Solids

The build-up of "sticky" solids is often a problem in rotating machinery, requiring continuous operator attention. The potential for solids accumulation in any part of the separator should be minimized in the design.

Enclosure

The unit should be enclosed and blanketed by an inert gas to contain hydrocarbon vapours and for occupational health and safety reasons.

2.4 Apparatus Type

The Centrax Separator must fulfill the processing needs of the Centrax Deashing Process. To do so, it must satisfy certain critical requirements which relate to the efficient performance of the process.

Mode of Discharge

The Centrax Separator must be continuous with respect to both liquid and solid feed and discharge.

Extraction

The Centrax Process achieves asphaltene and pre-asphaltene recovery by their dispacement from the compacted solids cake. This requires the solids to be sequentially - separated, compacted re-mixed with extractant, - and repeated as required. Thus, the mechanical separation must be configured to permit convenient solids movement between mechanical stages with appropriate conditions for re-mixing in stationary sections providing the required intensity of mixing. Furthermore, to minimize the quantities of extractant employed in the process, a counter-current flow arrangement is desirable. This means that the extractant should be able to move counter-current to the solids between the stages of the process, in a preferred Centrax processing arrangement.

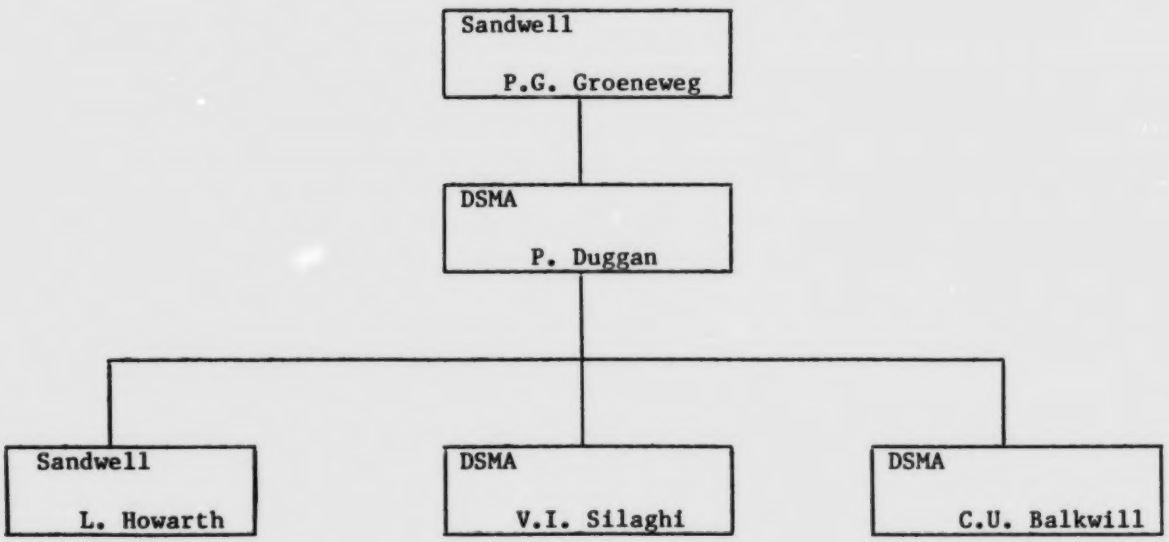
3.0 DEVELOPMENT OF DESIGN TEAM

The design specifications discussed in Section 2.0 were based on knowledge acquired by Sandwell's permanent staff working on the project. The translation of these needs into a conceptual mechanical design required the in-house development group to be augmented by others having complementary expertise in areas of:

- detailed mechanical design
- specification of parts and materials
- mechanical drafting
- finite element analysis of critical rotating parts
- sourcing of components and fabrication.

The possibility of obtaining this expertise from either university, industrial and consulting sectors was seriously considered and investigated. It was found that although those with academic backgrounds could provide some very sophisticated capabilities in the design area, other requirements could not effectively be met within the time schedule. At the same time, the design concepts were insufficiently defined in order to have industrial manufacturers estimate their costs and determine the skills and manpower required. Therefore, it was decided to engage the services of a consulting engineering company to provide the full range of services required. The firm of DSMA International Inc. of Toronto was subsequently hired as a result of their extensive design experience in precision rotating equipment (high performance wind tunnel fans), large drafting capability, knowledge of local fabricators, and commitment to the schedule.

Accordingly, a design team was established for the conceptual design study, which was kept intact through to the final engineering design. The structure of this design team was as follows:



4.0 CONCEPTUAL DESIGN STUDY

4.1 Initial Concept Study

The results of the conceptual development phase of the study are summarized in a report prepared by DSMA which is included in its entirety in Appendix 1. The concept at this stage of the development was for a separating machine characterized as follows:

- 3 identical centrifugal separator assemblies located in a triangular pattern inside a containment vessel,
- individual vertical-axis centrifugal separators,
- solids removal is achieved by a scrapper/pusher operating in a reciprocal motion, powered by a stationary hydraulic actuator. A tapered bearing arrangement is placed between the fixed hydraulic cylinder and the rotating scrapper/pusher.
- the separator bowls are driven by an arrangement of toothed belt and pulleys, powered by a single, centrally located D.C. drive motor.

Included in Appendix 1 are engineering drawings of the "Centrifugal Separator Assembly" and the individual "Centrifugal Separator Sub-Assembly".

Although the conceptual design was based on a multi-stage arrangement, it was decided to pursue the design of a single-stage, but multi-functional unit, for several reasons.

- the significant hardware design questions and novel equipment concepts can be investigated in a single stage,
- successive processing stages can be simulated by the use of a single separator sub-assembly,
- financial resources of the project can be concentrated on the key technological components of the design, rather than fabricating multiple units of the same unproven design.

Accordingly, it was decided to continue with the design further before beginning the detailed design. This interim stage was directed toward the furtherance of the design concepts along the lines of single stage unit, which could be used to simulate various stages of the process operation. As well, certain design assumptions were reviewed from a process standpoint before a commitment to detailed design was undertaken.

4.2 Interim Development Study

Following completion of the concept development study, it was decided to review and revise the design as required, before commencing detailed engineering. As a result of this intensive evaluation of the expected performance, operability, fabrication and cost of the prototype unit, several aspects of the conceptual design were modified.

These design revisions are discussed in the Interim Development Report included as Appendix 2. Briefly, the principle design changes were:

- the pusher stroke was extended to the full length of the bowl due to concern over the consistency of the centrifuged cake,
- this required a re-design of the mechanical drive assembly and relocation of the liquid take-off ports to the upper edge of the bowl,
- a surface around the upper edge was contoured to provide a smooth exit for the cake. A "plough separator" contour around the liquid port was designed to prevent blockage of the liquid ports by solids cake without impeding the flow of liquid through the liquid port,
- the original stationary hydraulic cylinder was replaced by a rotating hydraulic cylinder. The hydraulic oil is transmitted to the internal rotating cylinder by a dual channel rotary union.
- the containment vessel was designed to suit the multi-functional use of the single sage unit. A solids collection hopper and solvent trough were incorporated within a single containment vessel. An adjustable deflection shield arrangement was designed to be mounted to the underside of the vessel cover to direct the ejected solids to the appropriate receiver.

Appendix 2 includes drawings of the revised design of the separator unit and of the bowl and drive sub-assembly. It was decided to proceed to detailed design of the prototype based on the modified design concepts of the interim development study.

4.3 Detailed Design of Prototype 1

The design concepts established in the interim development report were used for the basis of the detailed design of the multi-functional, single-stage Centrax Separator. A complete set of the 13 detailed design drawings for the fabrication and assembly of the prototype unit are presented in Appendix 3 of this report.

Photograph 2. Stationary housing for rotating scraper and drive mechanism. Note connections for upper bearing water channel cooling.

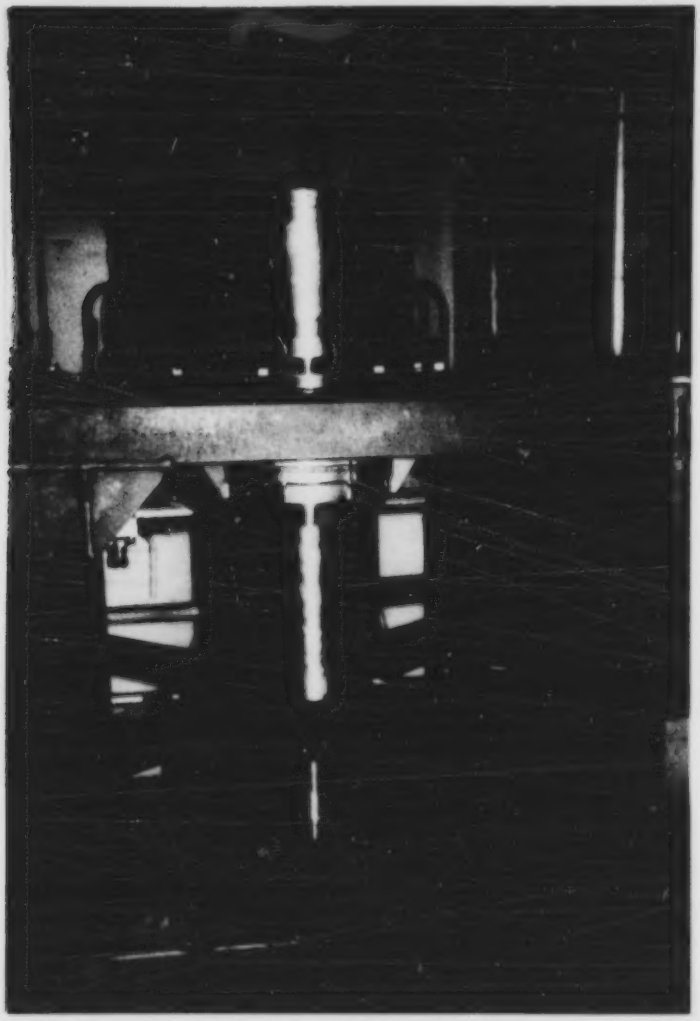
Appendix 3 also includes minutes of meetings dealing with additional design considerations, including the control system for the hydraulic cylinder which controls the movement of the pusher (scraper-piston). The pusher position control system is an important feature of the Centrax Separator. It provides independent control of the solids residence time within the unit and a capability to readily adjust solids retention for best performance. The control system permits infinite control of the bottom position dwell time, pusher ejection, stroke speed and distance, pusher retraction speed, and interruption of slurry feed during ejection sequence. This system, together with the novel take-off port design, allows for solids removal at full rotational speed of the unit and overall continuous slurry feed and solids discharge.

The expected capacity of such a full scale unit with a bowl diameter of 950 mm is in the range of 3-30 m^3/h of coal liquefaction feed slurry. Capacity is very dependent on the particle size distribution of the suspended solids in the feed and the requirements for centrate clarity. In addition, capacity is a function of a number of physical properties of the feed material and of the mechanical design details of the separator which effect attrition and or agglomeration of the feed solids, and those that control the flow patterns within the separation zone. More exact capacity figures can only be obtained by separation tests for each specific application.

On the basis of the final detailed design drawings, the prototype unit was advanced to the stage of fabrication and assembly.

Photograph 3. Solids discharge lip and liquid take-off port (plough separator)

Photograph 4. Stainless steel separator bowl and detachable discharge lip. Scraper plate not in place.



Photograph 5. Assembled bowl and drive mechanism in support frame. Note belt drive, DC motor and rotary union.

5.0 FABRICATION, ASSEMBLY AND COMMISSIONING

5.1 Fabrication

The next stage in the equipment development was the building of the first Centrax Prototype Separator. This unit was fabricated using Canadian suppliers and local precision machine shops and fabricators. Quotes were sought based on the design package from several suppliers and all major fabricators were visited and investigated. Important criteria in the sub-contractor selection was:

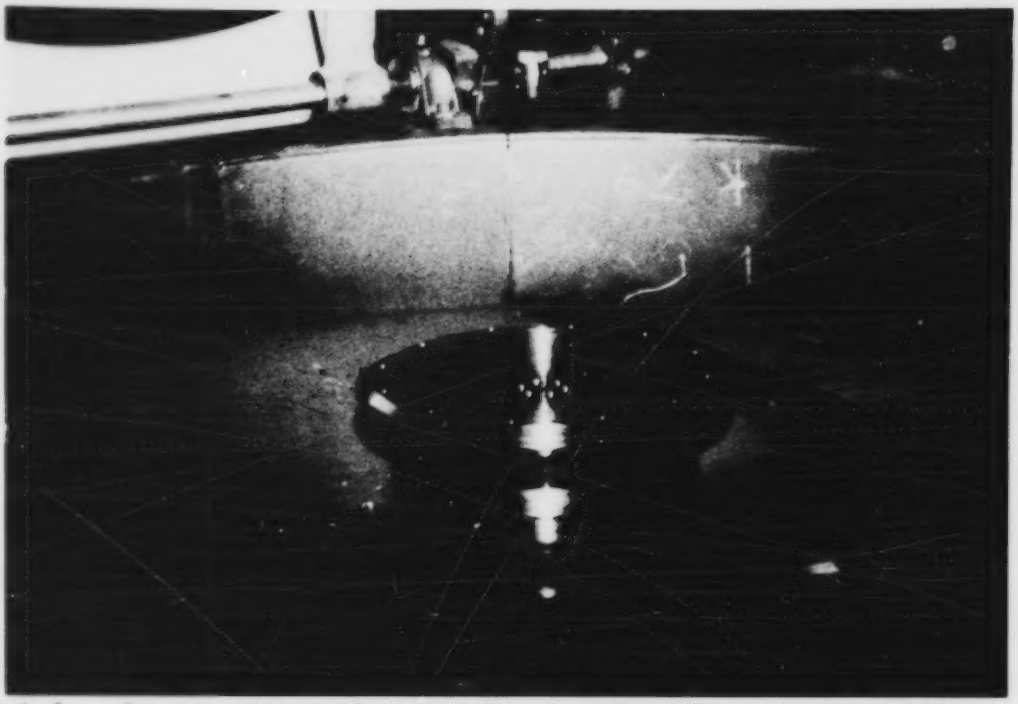
- similar experience
- quality control procedures
- suitability of equipment
- commitment to schedule
- ability to work out any difficulties in fabrication.

The fabrication of individual assemblies were sub-contracted to three Toronto-area fabricators as listed below.

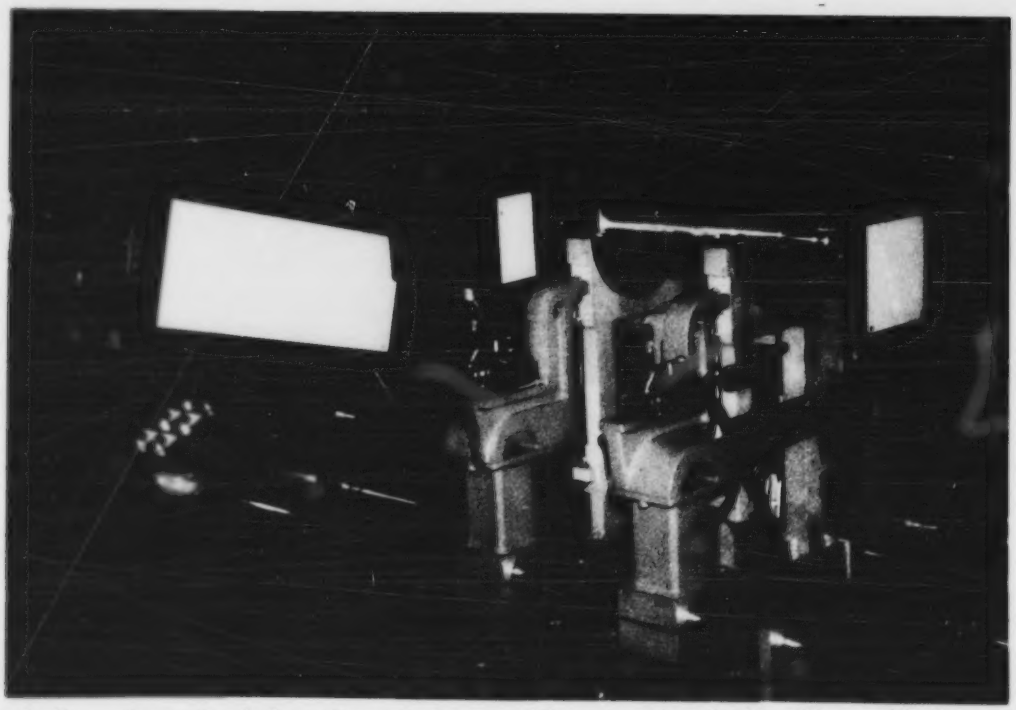
Centrifugal Separator Details	Horn Industries Ltd. 1111 Finch Avenue West Unit 28 Downsview, Ontario M3J 2E5
Containment Vessel Details	NOW & Associates 452 Bowes Road P.O. Box 240 Concord, Ontario L4K 1B4
Hydraulic Power Pack	National Hydraulics Ltd. 580 Oster Avenue Concord, Ontario L4K 2C1

In addition to these outside fabricators, Sandwell Technologies undertook the construction of auxilliary equipment for preparing, feeding and collecting process streams around the separator unit. This included:

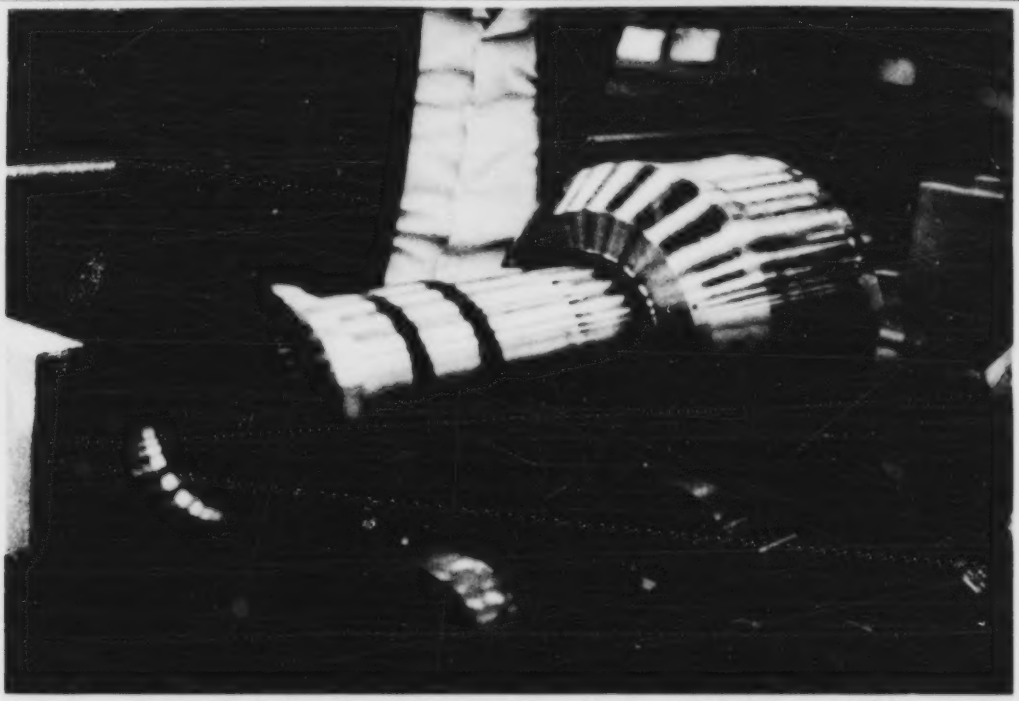
- four stirred and heated 100 l feed and collection tanks
- nitrogen blanketing



Photograph 6. Scraper plate undergoing dynamic balancing prior to assembly



Photograph 7. Dynamic balancing of internally rotating hydraulic cylinder at Orenda, Division of Hawker Siddeley Canada.



Photograph 8. Dynamic balancing of Separator bowl and drive assembly at Orenda, Division of Hawker Siddeley, Canada.

Photograph 9. Auxiliary equipment under construction at Sandwell Technologies in support of Centrax prototype unit.

- temperature and level measurements

- fume collection and condensation

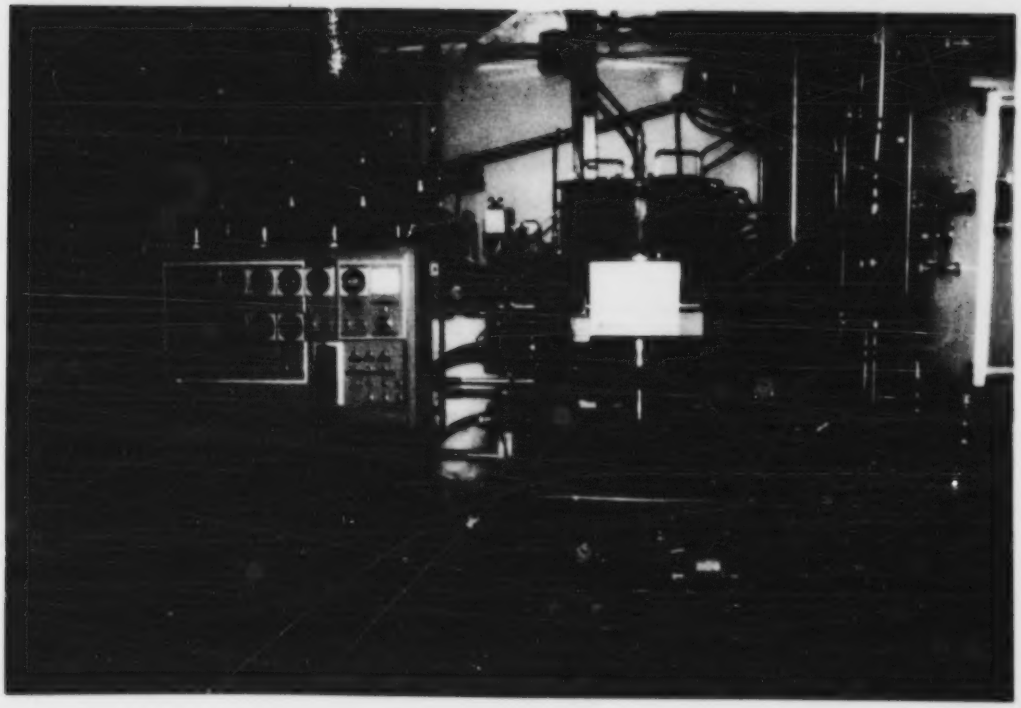
This peripheral equipment was designed and installed by Sandwell's own staff to accommodate the Centrax Separator at Sandwell Technologies' laboratories.

5.2 Assembly

It was considered to be very important to properly balance, both statically and dynamically, the rotating parts of the prototype. This work, as well as sub-assembly, was contracted to the Orenda Division, of Hawker Siddeley Canada. Expert engine technicians balanced, then assembled the separator sub-assembly. The assembled unit was then dynamically-balanced. The assembled and balanced unit was then installed in the support frame in the testing laboratories of Sandwell Technologies. Final assembly of all components were performed by Sandwell's technicians and operators prior to commissioning.

5.3 Commissioning

Upon completion of the assembly, the unit was tested thoroughly before processing any slurry. The completed unit is shown in the photographs included in this report. Details of the unit's commissioning and early operation with slurries will be discussed in the Phase III report.



Photograph 10. **Complete Centrax prototype unit showing control panel and hydraulic power unit located under the drive unit.**

6.0 CONCLUSION

The work described in this report has resulted in the development of a prototype centrifugal separator having features specifically required for the implementation of Centrax Deashing on a commercial scale. The following itemizes those features related to both process needs and the mechanical performance requirements of Centrax Separators.

Listed below are the majority of features of the Centrax unit:

PROCESS

- o Handles non-filterable solids
- o Discharges solids directly into a transfer medium to allow for:
  - --relatively trouble-free transfer of difficult materials
  - --complete redispersion of solids for effective extraction
- o Discharge rate of solids can be varied over a wide range, which has as implication:
  - --operation of the unit is not fixed with regard to:
    - --clarity of overflow
    - --dryness of solids cake
  - --the same unit can handle:
    - --solids of widely different size distributions
    - --solids of different relative densities
  - --the same unit is capable of:
    - --separation of solids from concentrated slurries for bulk solids removal
    - --separation of solids from very dilute slurries for clarification to the ppm concentration
- o Process has been tailored to make possible operation at atmospheric pressure
- o Unit is completely enclosed which allows for operation in, for instance, an inert gas environment and/or contain harmful or noxious vapours
- o Operates as a continuous unit operation (although the 'internal' operation is semi-continuous).

MECHANICAL

- o No thrust load on bearings
- o Wear on bowl and scraper by solids discharge is limited to scraper wear ring
- o Wear on scraper wear ring is minimized by the application of a relatively low speed differential between the ring and the solids
- o Operating environment is essentially isolated from the

drive mechanism with regard to transfer of mass:
--solids
--liquids
--vapours

- Unit has the capability of operating at relatively high temperatures without unduly overheating the drive mechanism by means of:
  --minimizing the flow of heat between the operating environment and the drive mechanism
  --built-in heat sink, which transfers the 'leaked' energy from the operating environment and the energy generated by the mechanical drive system to a water-cooled heat exchanger
- Design provides for free access to the operating part of the unit to facilitate inspection, cleaning, and maintenance when required
- Operating mechanical features can be altered to suit specific separation requirements without changing the drive mechanism within limitations
- Unit has been designed to allow for addition of additional units with the minimum of interstage transfer equipment to allow for efficient multi-stage extraction/separation
- Special emphasis was placed during the development phase on the objective of accomplishing the process requirements by the simplest mechanical ways to achieve high mechanical reliability

To summarize, the capabilities of this unit which distinguishes it over other centrifugal devices are:

- handling of any type of solids
- operation at relatively high temperatures
- essential complete separation of operating environment and drive mechanism
- independent control of liquid and solids residence times to allow for performance optimization of slurries with different separation characteristics
- capability of discharging the solids directly into a transfer extraction medium to provide a mechanical means of high intensity multi-stage solids/liquids extraction.

SANDWELL BEAK RESEARCH GROUP

Centrifugal Separating Machine

Concept Development Report

Report Number : 4053/R105

May 1984

Copy Number :

DSMA International Inc.
Toronto, Canada

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APPENDIX A Separator Specification
APPENDIX B Minutes of Meetings

1. INTRODUCTION

This report is submitted by DSMA International to Sandwell Beak Research Group in fulfillment of a contract for the concept development of a Centrifugal Separating Machine. This machine is required as part of a Research Development Programme undertaken by SBRG to develop an advanced, continuous, de-ashing process for coal liquefaction. The scaled unit considered here will be operated in conjunction with a pilot facility at the SBRG Mississauga laboratory within the next five months for further development and testing.

The scope of the study was to:

- review existing centrifuge designs
- define the Centrifugal Separating Machine requirements
- develop potential mechanical separator designs
- investigate the ability of these systems to satisfy the performance and operational criteria established for the machine
- develop hardware cost and schedule information for the manufacture of the pilot separating machine
- develop engineering cost and schedule information for detailed engineering required to complete the design of the pilot separating machine

A one page SBRG Specification for the system is attached as Appendix A.

The concept study was undertaken with close cooperation between SBRG and DSMA, and the design concepts described herein are the result of this liaison.

The preliminary requirements for the separating machines were defined during an initial meeting held at SBRG on April 16, 1984. Subsequently, design concepts were discussed at several review meetings and the minutes of these meetings, which form an integral part of this document, are attached as Appendix B.

2. REVIEW OF REQUIREMENTS

The basic specification for the Centrifugal Separating Machine, attached as Appendix A, is detailed below.

Physical Properties of Processed Material

solid concentration of feed	5 - 20% W/W
particle size	0.1 - 100 µm
particle density	1.3 - 2.5 g/cm^3
solution density	0.9 - 1.1 g/cm^3
viscosity of liquid phase	unknown
composition of solids	coal + ash
composition of liquid	low - very high MW oils
character of wet solids	abrasive - 'sticky' - non-flowable
character of dry solids	abrasive - non-sticky - flowable - dusty
filterability of solids cake	non-minimal

Operating Conditions

temperature	up to 200°C in one part and up to 600°C in one other section
pressure	atmospheric
residence time	3-10s in each stage
centrifugal force in rotational part of equipment	3000 G +
throughput capacity - slurry feed	0.5-4 USGPM
- cake	15-400 kg/h
- liquid phase	0.3-3.6 USGPM

condition of discharged solids	'bone dry' (0% liquid)
concentration of 'ash' in liquid overflow	less than 0.01% W/W
mixing intensity in stationary part of equipment	high and low shear

Mechanical Requirements

fabrication	no bearings or seals in contact with slurry minimum number of parts are to be standard, or machinery requirements are to be minimal and non-complex
maintenance	low
build-up of process material	none
control	automatic/manual

Type of Apparatus

mode of discharge	liquid and solids continuous
mode of feed	continuous
extraction section:	
separation parts	relative high velocity rotating sections to effect separation by centrifugal force
mixing parts	stationary sections with high-low-shear mixing

mode of operation	counter-current
solvent recovery section	high temperature continuous film flash evaporation/condensation
Scale-Up	13,000 USGPM of slurry feed

During subsequent meetings these requirements were confirmed and further design criteria established as follows.

Three individual centrifuge assemblies are required, operating in series within a containment vessel. Slurry entering the system from the coal liquefaction process passes from one centrifuge to another with extracted solids being mixed with solvent from an adjacent centrifuge in a counter current process.

The insulated containment vessel will be sealed to prevent leakage of hydrocarbon vapours and to maintain a constant temperature environment for the process.

To eliminate corrosion and contamination effects, no bearings or seals are to be in direct contact with the slurry and bearings will be located at a level where temperature effects are minimized. Centrifuged solids, deposited on the inside surface of the separator bowl, are to be removed in a continuous manner by a scraper assembly and deposited in an adjacent solvent tank. Suitably sloped surfaces within the separator bowl will ensure that liquids will flow over the deposited solids and exit through ports around the bowl circumference.

The inside surface of the bowl will be polished to reduce the friction coefficient between the bowl and deposited solids in

order to reduce the axial loading on the scraper assembly and prevent break up of the cake. The scraper assembly will be designed to remove a minimum 20 mm and a maximum 30 mm of deposited solids per stroke, with a stroke every 3 seconds.

Corrosion resistant stainless steel materials are to be used for separator and containment vessel construction.

Space is to be provided within the containment vessel for a fourth separator assembly to be added in the future. This space will be used as a location for a solvent storage tank in the initial pilot plant assembly.

3. DEVELOPMENT OF CONCEPTS

3.1 Review of Existing Designs

Prior to the development of conceptual designs for the Centrifugal Separating Machine, several commercially available centrifuge designs were reviewed.

These centrifuge designs fall into two general categories: the scroll/decanter style and the pusher/scraper style. The scroll/decanter style incorporates a central screw assembly with blades rotating at a speed slightly above or below the centrifuge speed. The purpose of the rotating blades is to push deposited solids continuously along the surface of the bowl while separated liquids pass through the porous wall of the centrifuge bowl. The close tolerance requirements between the scrolling blades and the bowl surface demand that the central scroller shaft is rigidly supported at both ends by bearing assemblies. For the SBRG requirements, this design has several disadvantages. Since the slurry to be centrifuged must be piped to the axis of the separator, a central support shaft for the scroller blades would require many perforations in order to permit free passage of the slurry. In addition, the SBRG design cannot incorporate a porous wall since centrifuged liquid flows over the surface of the deposited cake and must therefore pass through perforations in the scrolling blades in order to reach the bowl liquid exit ports. The "sticky" nature of the SBRG centrifuged material could also lead to solids being deposited on the scroller blades tending to block the liquid perforations, and preventing the removal of solids from the rotating bowl. The requirement for a scroller shaft bearing support within the container vessel also poses a problem for the SBRG process, since bearings would be required to operate at high

speeds in a hot and corrosive environment with associated lubrication difficulties and rapid bearing wear. It was jointly concluded by DSMA/SBRG that in view of these potential operating problems and fabrication complications the scroller/decanter style of separator would not be pursued further.

The pusher/scraper style of centrifuge incorporates a central piston which rotates at the same speed as the centrifuge bowl, in order to minimize abrasion effects, and propels the deposited solids cake down the axis of the bowl. The centrifuged liquid flows over the surface of the cake and exits through the ports provided. This design has the advantage that support bearings may be isolated outside the container vessel reducing the effects of contamination and high temperatures. Additionally, design and fabrication of the assembly is simplified by the ability to employ standard machining practices and conventional tolerances between rotating components of the drive system. One disadvantage of this system, however, is that a separate drive system is required to control the scraper motion in the axial direction and the scraper piston may be heavily loaded.

3.2 Critical Considerations

An early requirement established for the Centrifugal Separating Machine was that slurry feeds to the individual centrifuges would be by gravity only and this led to a conclusion that feed pipes must terminate at the entrance to the bowl if the centrifuges are to be installed in an inverted position. An inverted orientation was initially preferred, since the solids ejected by the scraper could then fall directly to the solvent tank below. In order to subsequently feed the slurry to the upper end of the separator bowl, a conical conduit was required, to be supported from the

underside of the scraper piston. Concern that the incoming slurry may stick to the conical conduit and the difficulties in providing support for this conduit led to the conclusion that the separator assembly should be reorientated with its open end uppermost, permitting the slurry feed pipe to terminate at the bottom face of the bowl. This meant that the solvent tank for solids collection must be wrapped around the open end of the separator bowl in order to preserve the head required for gravitational slurry feed.

By adopting the pusher/scraper style of separator an initial intention was that the rotary motion of the bowl and scraper could in some compact form be converted into the desired axial reciprocation of the scraper piston. In order to achieve this goal, a compact gearbox would be required to convert the 4600 rpm bowl rotation into the 20 rpm considered suitable for the equivalent reciprocating motion. An additional mechanical device would then be required to convert the motion from a rotary to reciprocating direction. The use of Cyclo and harmonic drives was investigated for this purpose, but the mechanical complications introduced and the potentially high axial loading of the scraper piston led to the conclusion that this was a high risk approach which should not be pursued further.

Detail design of the separator bowl is another area of concern since the successful operation of the process depends upon efficient separation of the solids and liquids within the bowl. Several bowl configurations and associated liquid exit port designs were considered in the course of the study and it was agreed that the bowl assembly should be designed in a manner which permits simple replacement at a later date if changes in bowl geometry seem desirable.

4. EQUIPMENT DESCRIPTION

A conceptual design for the Centrifugal Separating Machine is shown on Drawings E4053-001 and E4053-002. The arrangement shown employs three identical centrifugal separator assemblies located in a circular pattern around a containment vessel. Solids and liquids extracted from the separators flow around the circuit in a counter current fashion and from the final separator, solids are deposited, via a hopper unit, into a portable container ready for oven drying. Space has been allocated within the container vessel for a fourth separator assembly to be added at a later date and a solvent tank is currently shown in this location.

The individual separator assemblies are driven at the desired rotational speed by an arrangement of toothed belts and pulleys, powered by a single, centrally located D.C. drive motor.

4.1 Separator Bowl

The purpose of the separator bowl is to provide a surface for the deposition of centrifuged liquid and solid cake. Solid cake is deposited to a thickness of 10 mm directly on the inside surface of the bowl and centrifuged lqiuid flows over the cake to exit through ports installed at the mid-length of the bowl. Exiting liquid is directed away to the next process stage by a conduit wrapped around the outside circumference of the bowl. The geometry of the bowl has been selected to encourage the easy passage of the solid cake "sleeve" up the bowl surface under the action of the scraper piston. A nominal bowl diameter of 250 mm was selected, rotating at a speed of 4600 rpm, in order to achieve the specified 3000 g slurry acceleration. An initial diverging section is intended to encourage the deposited cake to crack in

order to release the maximum quantity of liquid. A subsequent converging section is designed to deter the flow of liquid down the bowl and milled segments in this section encourage the cake to break up, in an orderly fashion, and without restriction, before being thrown clear of the bowl by the centrifuge action. A nominal bowl thickness of 5 mm has been selected for the bowl in order to minimize tangential stresses caused by a combination of centrifuge action and the radial loading from deposited cake.

The conceptual design has been based upon the use of 316 stainless steel as the bowl material in order to withstand the corrosive environment within the container vessel. A 1/2" diameter feed pipe directs the flow of slurry to the base of the separator bowl. The liquid exit ports in the bowl circumference are designed to ensure the minimum of restriction to the movement of the solid cake without hampering the liquid flow to the external conduit.

4.2 Scraper Assembly

The scraper assembly is designed to push the deposited solid cake up the bowl surface at regular intervals with an equivalent quantity of cake being ejected to a surrounding solvent tank. This is achieved by the action of a close fitting piston, complete with sealing rings, which reciprocates over a maximum stroke length of 30 mm. The scraper assembly rotates at the same speed as the separator bowl in order to minimize abrasive effects on the scraper surface. The scraper sealing rings serve to prevent the migration of solid cake particles behind the piston and holes drilled through the piston surface allow the space behind the piston to breathe. In the event that any cake particles do migrate to this cavity, slots machined in the outer wall of the bowl ensure that they will be ejected to the container vessel by the centrifugal action.

4.3 Bowl/Scraper Drive System

4.3.1 Mechanical System

The separator bowl is projected into the container vessel in a cantilevered form by a central shaft supported by an arrangement of precision, high speed bearings. A duplex pair of angular contact bearings at the lower end of the drive shaft supports the bowl thrust loads and radial loads are shared with a bearing mounted at the upper end of this shaft. This arrangement permits small axial movements of the drive shaft due to differential temperature effects without increasing the axial loading on the support bearings.

The scraper drive shaft is driven at the same rotational speed as the bowl by an interconnecting spline arrangement which also permits up to 30 mm unrestricted axial movement of this shaft. A heavy duty, hydraulic actuator, driving axially through a tapered bearing arrangement within the scraper shaft, provides the reciprocating motion required for the scraper.

Bearing sizes have been selected on the basis of grease lubrication at an operating speed of 4600 rpm in order to avoid the complications and costs associated with the use of oil lubrication or oil mist systems.

A labyrinth seal arrangement at the upper end of the drive assembly is used to prevent contamination of the bearings by hydrocarbon vapours from the container vessel and the cavity behind this labyrinth is purged with dry nitrogen to enhance the sealing effect. A conventional lip seal arrangement is used to seal the lower end of the drive assembly.

Drilled passageways within the drive system housing are provided to allow regular grease lubrication of the support bearings and spline assembly. A toothed pulley, secured to the bowl drive shaft, is powered by a central drive motor through a toothed belt.

4.3.2 Electrical System

In order to rotate the bowl/scraper assembly, several variable speed drive systems have been considered. The requirement for a negative torque for forced deceleration, in addition to the forward torque requirements, generally favours direct electrical drives. Adjustable mechanical drives are considered inappropriate for this purpose.

Electrical drives considered include; variable frequency A-C, eddy-current clutch/brake and DC variable speed drives. The DC drive system is the most appropriate selection from both simplicity and a cost point of view. It offers high starting and accelerating torque, and the use of a simple dynamic braking arrangement, dissipating negative torque in a load resistor, offers an economical and reliable deceleration control.

The A-C variable frequency drive using a similar dynamic braking scheme costs approximately the same as the DC drive. However, its negative torque absorption capability decreases with speed, as the motor's absorption field is self-generated and is speed dependent. A regenerative control scheme could be used for more rapid deceleration, but it is more costly and quite complex.

An eddy-current clutch/brake drive could be used, but when sized for the required acceleration and deceleration torques costs more than the simpler DC drive.

The DC drive system has a rated speed of 2500 rpm and when sized for a starting and accelerating torque of 22 lb-ft (12 lb-ft at the load), will accelerate the separator at full operational speed in approximately one minute. A decelerating torque of two to four times this is possible by appropriate sizing of the dynamic braking resistor and selection of the field excitation current. The deceleration field current level will be adjustable and can be pre-set for the desired deceleration torque.

4.4 Containment Vessel

The three separator assemblies with their associated solvent tanks, interconnecting pipework and supply pumps are housed within a circular, stainless steel, containment vessel. This vessel is sealed, insulated and heated to maintain an internal ambient temperature of 180°C. The separator assemblies are inserted from beneath this vessel and secured to mounting flanges supported by a rigid structural support frame. Solvent tanks which collect the centrifuged cake are supported by the upper flange of the container vessel with angled deflector shields to direct the cake into the solvent. Turbine mixers, projecting through the upper support flange serve to thoroughly mix the cake and solvent with the mixer drive motors safely installed outside the container vessel environment. Eductors attached to the outlet end of the solvent feed pipes propel the solvent into the mixer turbine. The process requirements are shown in Figure 1.

Glass panels mounted to the upper flange of the containment vessel act as process viewing widows and the panels to which these are mounted can be removed, allowing access to the separator bowl and annular solvent tank.

The central drive system arrangement of pulleys, right angled gearbox and DC motor are supported by the main structural base frame of the containment vessel. The vessel support legs are positioned at floor level supported by vibration isolation mounts.

4.5 Electrical/Control Systems

Figure 2 shows the proposed block diagram for the electrical/control system.

The separator drive requirements are discussed in Section 4.3.2. Since the design requirements for the slurry pump drives and the solvent turbine mixers have not been addressed during this study, little definition can be given at this time. It is assumed that all variable speed drives will be purchased as self-contained systems, complete with start/stop, speed adjustment and self-protection functions. Only external power is required at the correct power and voltage levels from the existing SBRG pilot plant facility.

The separator's scraper system will be controlled in a repetitive oscillatory pattern by a hydraulic cylinder. End limit switches, set for the desired stroke length and a simple relay control system can be used to reverse the directional hydraulic control valve, and hence the scraper direction, at each end of travel. A stroke frequency of approximately 20 cycles per minute is presently being considered. If frequent usage and long operating life is a requirement, consideration should be given to the use of solid state relays in the control logic.

The hydraulic power pack required for operation of the scraper can be purchased as a self-contained package complete with all protection equipment. The pump starter can either be self-contained or can be purchased as a separate item.

New power distribution equipment requirements must also be considered in conjunction with the existing spare/expansion provisions which already form part of the SBRG pilot plant operation.

5. DETAIL DESIGN REQUIREMENTS

Following the completion of the conceptual design phase for the Centrifugal Separating Machine, the detail design of the equipment may proceed.

Some specific areas which require further investigation during this phase, before detail design can be completed, are as follows:

Bowl stresses and deformations
Bowl geometry and surface finish requirements
Liquid exit port design
Rotating critical speeds and balancing requirements
Scraper loading and alignment
Drive shaft loading and alignment procedures
Bearing selection and lubrication requirements
Labyrinth/lip seal design and selection
Nitrogen purge system design
Rotating inertia calculations
Drive system sizing and alignment procedures
Scraper actuator sizing and selection
Actuator structural support requirements
Splined shaft design and lubrication requirements
Containment vessel design
Slurry feed pump selection
Tank insulation and temperature control
Observation window design
Gravity feed design
Solvent mixer selection
Solids removal system
Power distribution system requirements
Control system packaging

6. COST ESTIMATES

6.1 Hardware Estimates

The following are budgetary cost estimates for the procurement, fabrication, assembly and installation of the hardware required to produce a fully working Centrifugal Separating Machine to meet SBRG requirements. Where individual equipment has not yet been defined by SBRG (stirrers, pumps, etc.) allowances have been made in the budgetary estimate.

a) Centrifugal Separator Sub-assembly

Separator bowl, scraper piston, drive shafts, labyrinth/lip seals, support bearings, scraper sealing rings, scraper drive clevis assembly, drive pulley, hydraulic actuator, and drive system housing, assembled, ready for use (3 required) $ 11,200. Each

b) Containment Vessel

Tank weldment, support frame/legs, drive support structure, DC drive system, slurry pumps, stirrers, slurry tank, solvent tanks, observation ports, gearbox, drive pulleys, drive belts, piping/fittings, vibration isolation mounts, hydraulic power pack, valves/fittings, thermal insulation, heaters, control panel, power distribution system including mechanical and electrical installation $ 63,250.

TOTAL ESTIMATED HARDWARE COST - $ 96,850.

6.2 Engineering Services

An estimate for engineering services to be supplied to SBRG by DSMA for the detail design of the Centrifugal Separating Machine is indicated.

This estimate includes, detail engineering, preparation of shop drawings/installation schematics and the preparation of technical specifications in a form suitable for inclusion in a tender document.

Further estimates for DSMA assistance with manufacturer sourcing, assistance during fabrication/assembly, and start up/commissioning can be supplied as required.

It is proposed, that the detail design phase be undertaken by DSMA on a time-fee basis for engineering services with expenses reimbursed at cost. Fees would be based upon individual annual salaries according to the following formula:

$$\text{Rate} = \frac{(\text{Annual Salary} \times 1.045)2.25}{1720}$$

Expenses to be billed at cost would include:
Premium portion of any payments for scheduled overtime with prior approval of the clients; travelling subsistence allowance and other expenses incurred by DSMA personnel while travelling in connection with the project, in accordance with DSMA's normal practice; long distance telephone calls, telegrams, telex and other such means of communication made on behalf of the project; cost of blueprints and other reproductions associated with the work; computer services for technical calculations associated with design; and any other reasonable expenses incurred on the project with prior approval of the client.

SBRG would be kept advised on a regular basis of the hours accumulated on the project. Invoices would be issued monthly with a breakdown of the hours worked per individual and an itemized listing of expenditures billed at cost.

The following estimate is broken down on a sub-assembly basis. Design hours indicated include estimates for layout work, detail drawings and checking of mechanical drawings.

1. Containment Vessel Assembly

Design Draughting	Drawings	Est. Hours	Est. Cost
Vessel Assembly Drawing	1	60	2,580.
Tank Weldment Details	1	60	2,580.
Support Frame Details	1	60	2,580.
Separator Cover Details	2	120	5,165.
Solids Hopper Details	1	60	2,580.
Vessel Piping Schematic	1	40	1,700.
Hydraulic Schematic	1	40	1,700.
Sub Total		440 Hrs.	$18,885

Engineering Design	Est. Hours	Est. Cost
Containment vessel design including separator interface configuration, sealing requirements, drive system configuration, pump requirements and mixer selection	60	$ 3,450.
Tank weldment analysis including stress and deformation characteristics, stiffener selection and location and material selection	45	2,585.
Support frame analysis including stress/-deflection calculations, support leg definition, vibration isolation mount selection and dynamic effects of rotating separators	45	2,585.
Separator cover design including solvent tank configuration, deflector design, mixer interface requirements and design of observation window with appropriate seals	60	3,450.
Solids removal hopper design including selection of hopper geometry, interface requirements, collection container design and interface seals with containment vessel	35	2,040.
Piping configuration including selection of pipe/tube sizes, fittings and overall scheme with definitions of interfaces with solvent tanks, pumps, liquid exit ports and separator bowls	45	2,585.
Hydraulic system design including power pack selection, circuit design, control valve selection, and piping details	60	3,450.
Sub Total.....	350 Hours	$ 20,145.
Estimated Expenses		1,300.
CONTAINMENT VESSEL TOTAL		$ 40,330.

2. Centrifugal Separator Sub-Assembly

Design Draughting	Drawings	Est. Hours	Est. Cost
Separator Assembly Drawing	1	80	$ 3,840.
Separator Bowl Details	2	160	7,080.
Scraper Piston Details	2	160	7,080.
Drive Housing Details	2	160	7,080.
Actuator Support Details	1	60	2,580.
		620	$ 27,660.

Engineering Design	Est. Hours	Est. Cost
Separator assembly configuration including bowl/scraper interface requirements, material selection, seal selection, bearing selection and lubrication/purge techniques	60	$ 3,450.
Bowl design including stress/-deformation calculations, rotating intertia calculations, liquid exit port design, shear plate design and surface finish requirements	100	5,720.
Scraper piston design including interface with bowl, sealing ring selection, drive shaft design, sliding seal design, alignment procedures, stress/-deformation calculations, and rotating inertia calculations	100	5,720.

Engineering Design	Est. Hours	Est. Cost
Drive housing Design including bearing fits, lubrication require ments, bearing loads, critical speed calculations, labyrinth seal design, lip seal selection, drive pulley sizing and drive belt selection	100	$ 5,720.
Actuator design including hydraulic cylinder selection, thrust bearing design, lubrication requirements, actuator supports stess/-deflection calculations and selection of fastener types and sizes	45	2,585.
Sub Total....	405 Hours	$23,195.
Estimated Expenses		1,300.

CENTRIFUGAL SEPARATOR TOTAL - $52,155.

3. Electrical/Controls

Design Draughting	Drawings	Est. Hours	Est. Cost
Cable Block Diagrams	2	50	$ 2,400.
Scraper Control Circuit Schematic	1	40	1,920.
Electrical Connection Diagrams	2	50	2,400.
Power Distribution Diagram	1	20	960.
	Sub Total -	160	$ 7,680.

Engineering		
Electrical equipment configuration and definition of interconnecting cable requirements	40	$ 2,515.
Scraper control circuit design including logic design equipment definition, power supply selection, limit switch/relay selection and control hardware definition	40	2,515.
Electrical connection configuration including detailed equipment hook-up definition	80	5,030.
Power distribution design including review of existing SBRG supply system and definition of modifications and expansion required	40	2,515.
Preparation of detailed technical specification for drive system	30	1,890.

Engineering	Drawings	Est. Hours	Est. Cost
Preparation of detailed technical specification for equipment supply and installation		30	1,890.
Drawing Checks		30	1,890.
	Sub Total.....	290 Hours	$ 18,245.
Estimated Expenses			1,300.
	Electrical Controls/Total		$ 27,225.
	TOTAL ESTIMATED ENGINEERING COST		$119,710.

6.3 Schedule

Figures 3 and 4 show proposed schedules for several optional schemes to complete the detail design, fabrication, assembly and commissioning phases for the Centrifugal Separating Machine. These are intended to supply SBRG with a sequence of main activities and target dates for the completion of individual milestones with a range of options. Schedules are based upon the use of outside mechanical and electrical contractors. Further cost and schedule reductions may result by the use of SBRG technical personnel.

6.3.1 Option 1

The schedule which relates to Option 1 is indicated in Figure 3. This schedule is based upon the assumption that the detail design package for the separator assembly and containment vessel is completed by DSMA before any equipment fabrication is started, and that sourcing of suitable fabricators and the preparation of tender documents can be carried out in advance.

As the schedule indicates, the overall programme requires a total of twenty-five working weeks to complete, consisting of thirteen weeks for detail design, two weeks for tendering and contract award, eight weeks for fabrication and assembly and two weeks to commission the equipment.

6.3.2 Option 2

The schedule which relates to Option 2 is indicated in Figure 4.

By commencing fabrication of the separator assembly before design of the containment vessel has been completed an overall schedule

reduction of two weeks can be achieved. Due to the diverse natures between the fabrication techniques required for the high speed centrifugal separator and the more conventional containment vessel, it may in any case prove a more suitable strategy to select separate contractors for these units.

An early start on the fabrication of the separator assembly may also serve to highlight any potential manufacturing problems and permits the early procurement of long lead bought out components.

6.3.3 Option 3

Another strategy which may be employed to improve the overall schedule and reduce the technical risk associated with this equipment is to construct only one separator assembly and install the unit for test purposes in a reduced scale containment vessel.

Although the time required to detail design the separator assembly would remain unchanged, the change in scope for the containment vessel would reduce the overall design period by three weeks.

Corresponding savings would be made in the fabrication and assembly of the separator assembly and the containment vessel and electrical system installation requirements would be reduced in size and scope.

As Figure 4 indicates, the overall schedule can be reduced to seventeen weeks by adopting this approach.

A summary of these options and the associated hardware and engineering costs is shown in Section 6.3.4.

6.3.4 Summary of Options

OPTION	ENGINEERING ESTIMATE ($)	SEPARATOR ASSEMBLY ESTIMATE ($)	CONTAINMENT TANK ESTIMATE ($)	TOTAL COST ($)	COMPLETION SCHEDULE (WEEKS)
1	120,000	33,600	63,250	216,850	25
2	120,000	33,600	63,250	216,850	23
3	102,500	11,200	35,000	148,700	17

FIGURES

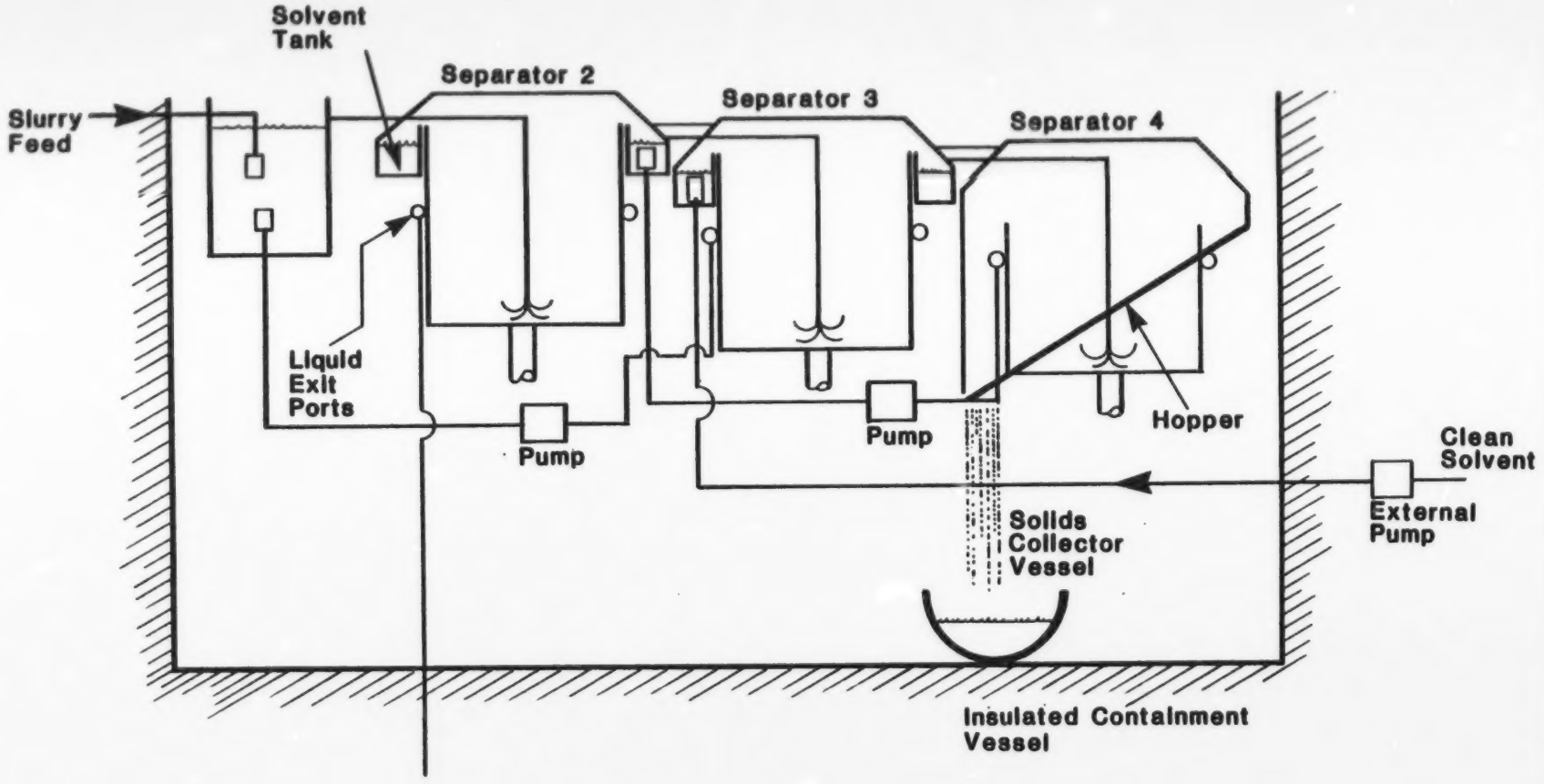

Figure 1. Process Schematic

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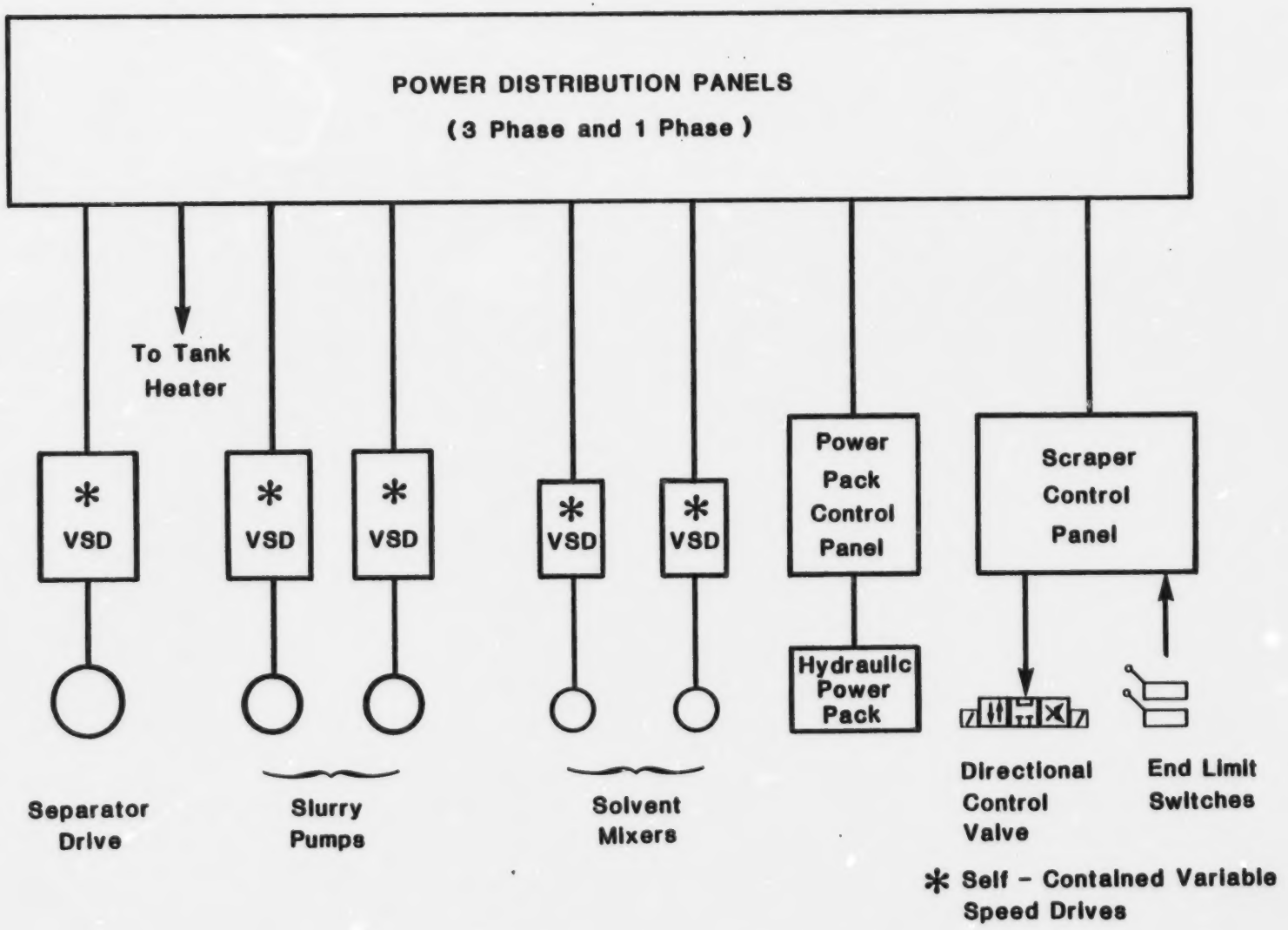

Figure 2. Electrical/Control System Block Diagram

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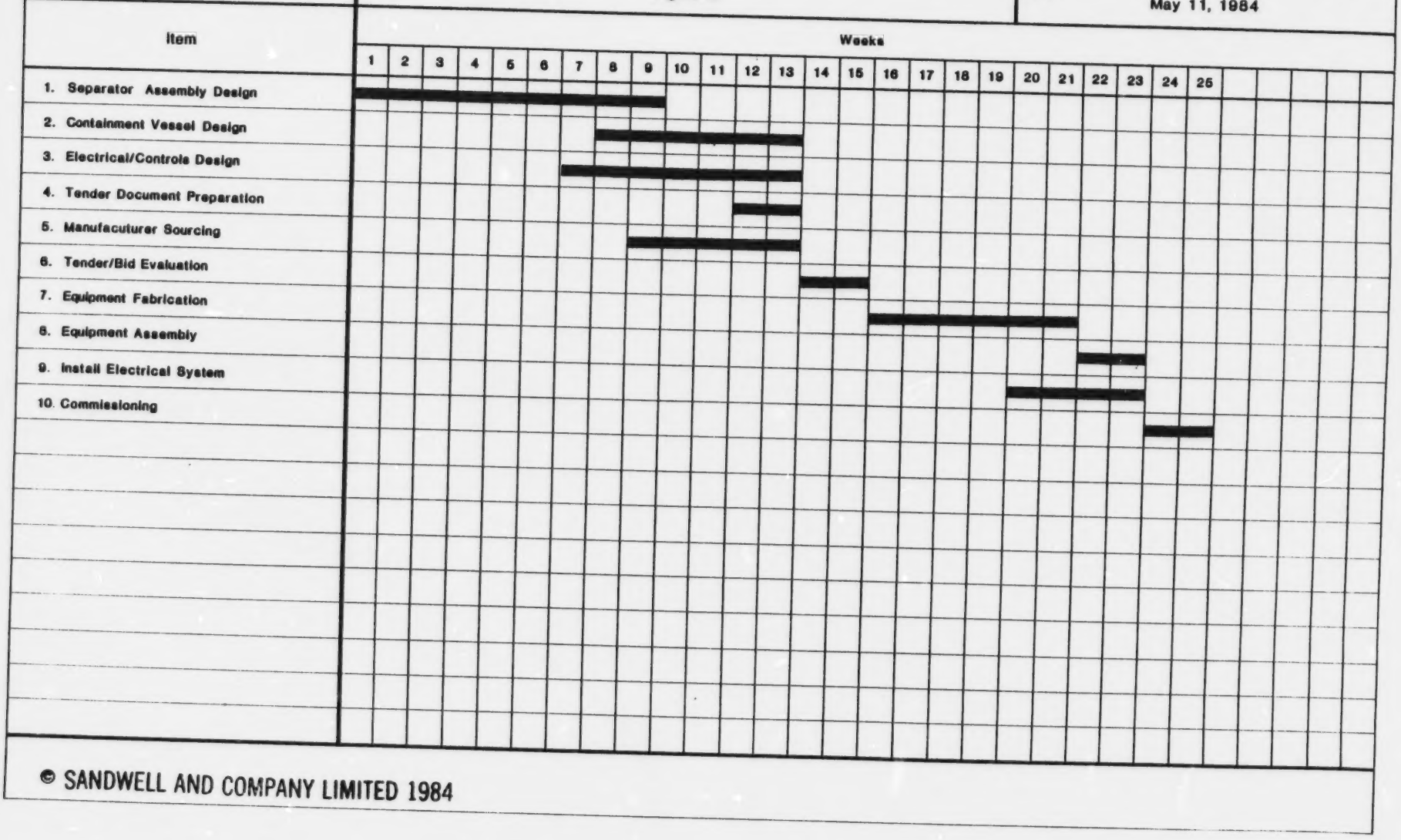
DSMA International Inc.
Toronto, Canada

Project : Sandwell Beak Centrifugal Separating Machine Schedule

Project No.: 4053

Figure 3.

Date: May 11, 1984


Item
Weeks
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
1. Separator Assembly Design
2. Containment Vessel Design
3. Electrical/Controls Design
4. Tender Document Preparation
5. Manufacturer Sourcing
6. Tender/Bid Evaluation
7. Equipment Fabrication
8. Equipment Assembly
9. Install Electrical System
10. Commissioning

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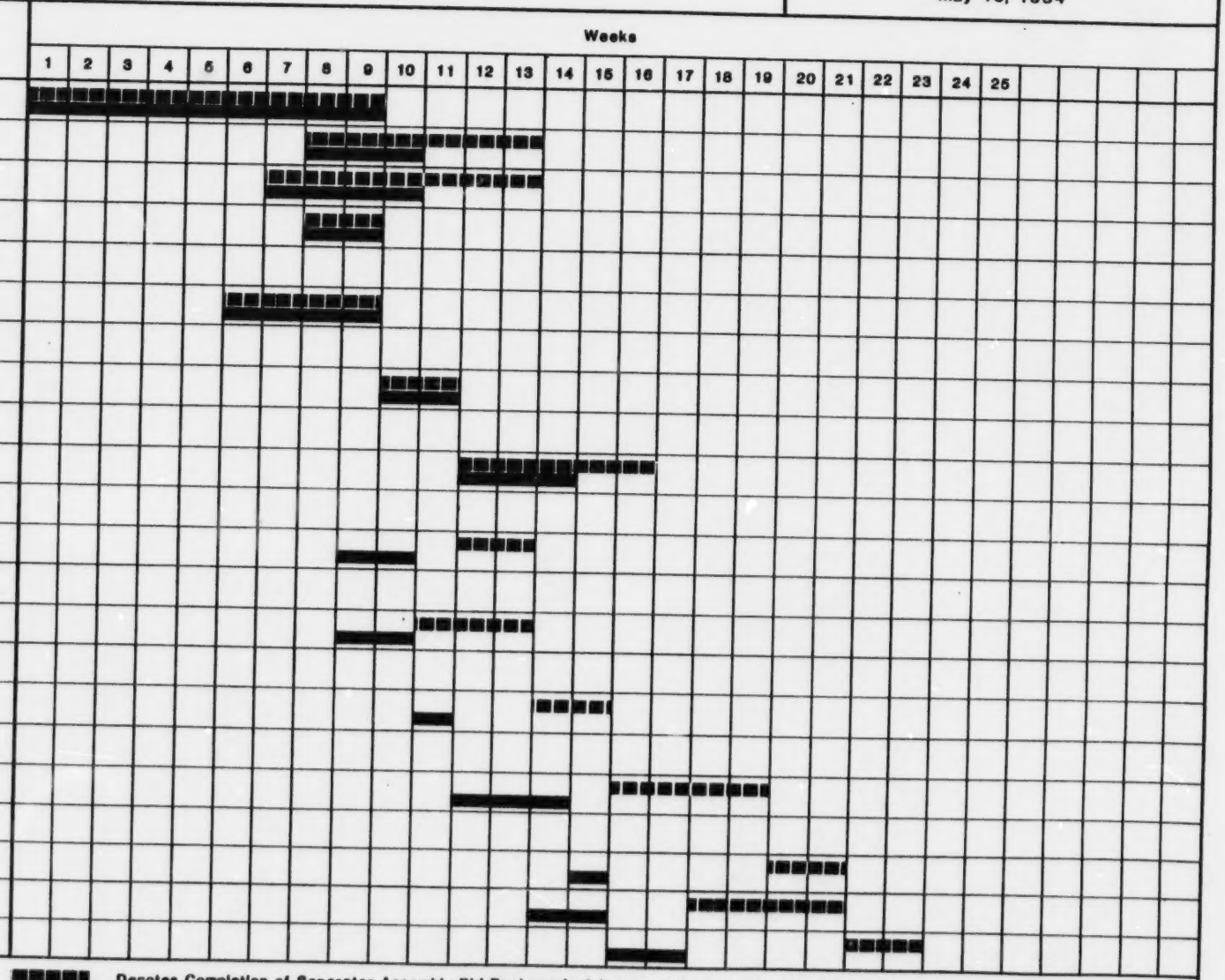
DSMA International Inc.
Toronto, Canada

Project : Sandwell Beak Centrifugal Separating Machine Schedule

Project No.: 4053

Figure 4.

Date : May 15, 1984



Denotes Completion of Separator Assembly Bid Package in Advance of Containment Vessel Design Package.

Denotes Fabrication of One Separator Assembly Only With Scaled Down Containment Vessel.

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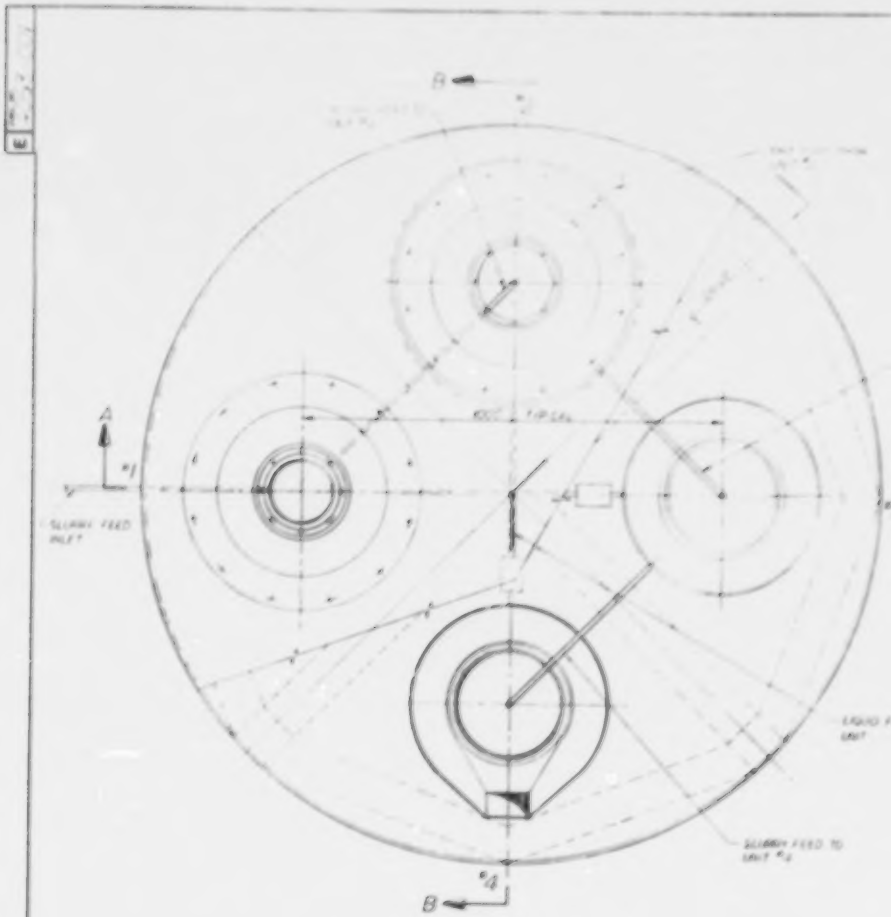
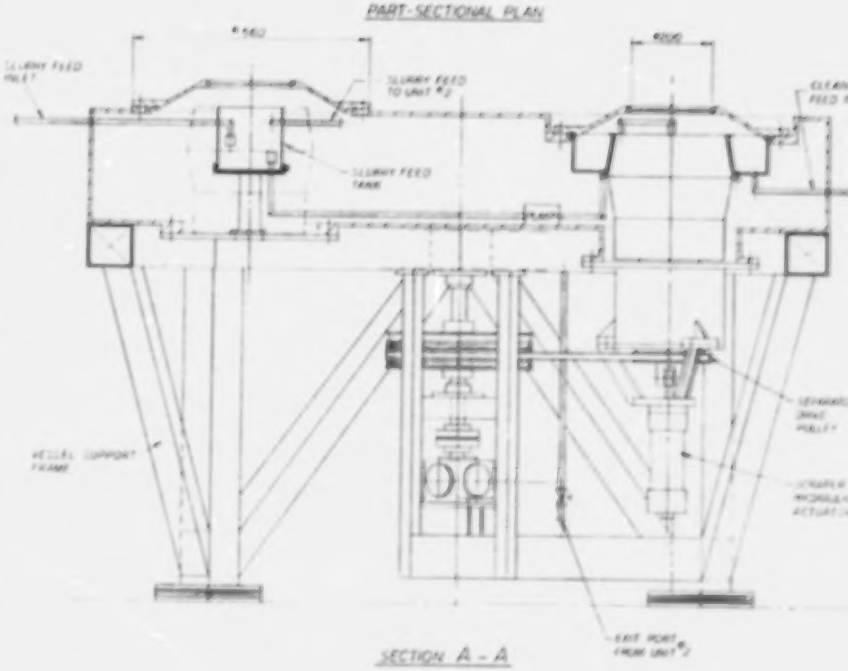
DRAWINGS



PART-SECTIONAL PLAN



SECTION A - A

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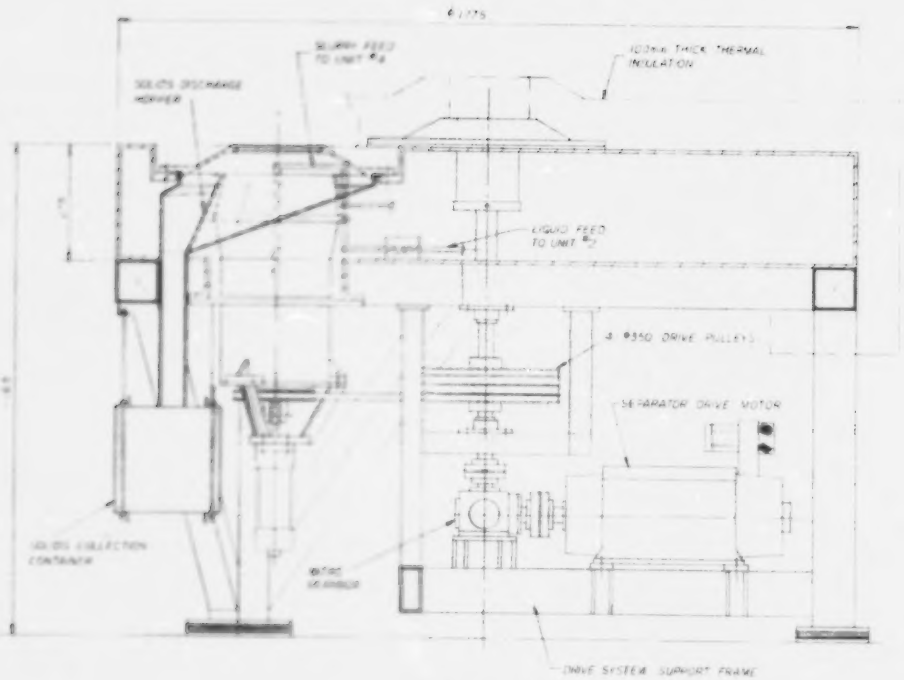


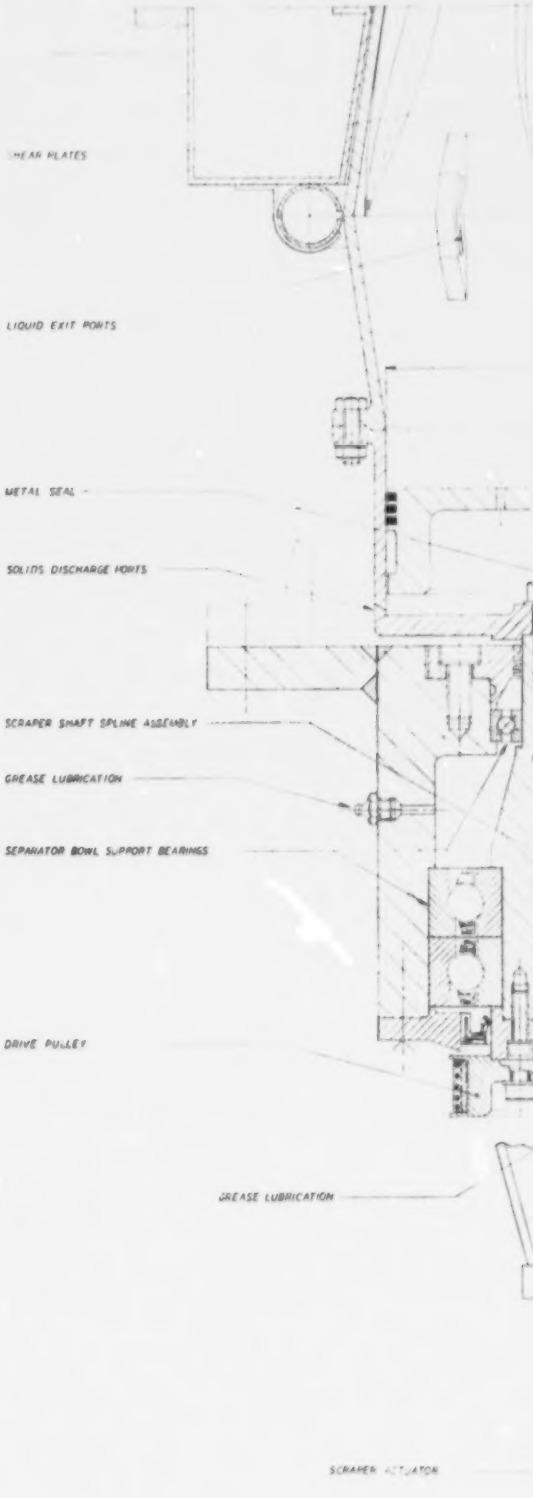
SECTION B-B

Sandwell Beak Research Group
Centrifugal Separating Machine

DSMA International Inc.
Engineers and Constructors
Toronto, Canada

CENTRIFUGAL SEPARATOR ARRANGEMENT

PROJECT			DRWG. NO.	ISSUE
4053		E	4053-001	



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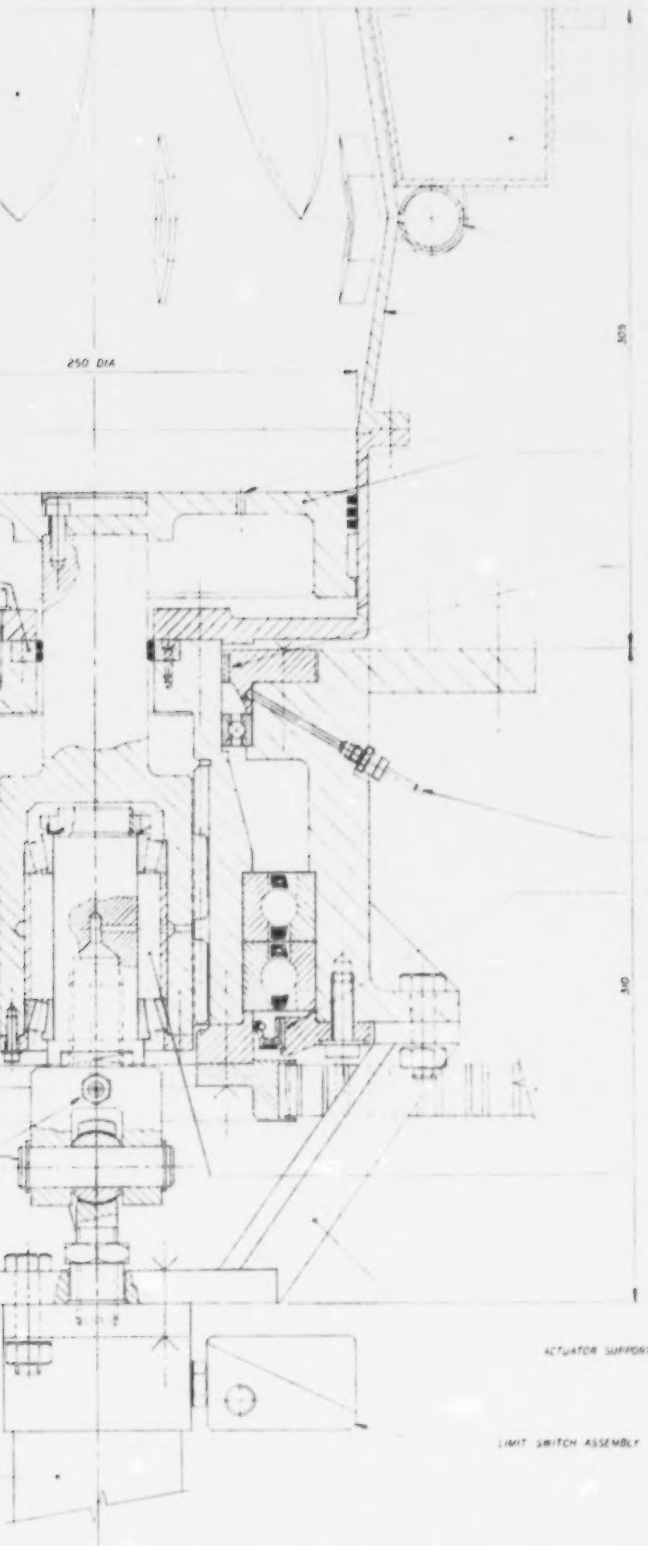


SOLVENT TANK

LIQUID COLLECTION CONDUIT

SEPARATOR BOWL

VENTS

SCRAPER PISTON

LABYRINTH SEAL

DRY NITROGEN PURGE

LIP SEAL

SCRAPER THRUST BEARING ASSEMBLY

ACTUATOR SUPPORT FIXTURE

LIMIT SWITCH ASSEMBLY

ITEM NO.	REFERENCE NUMBER

BILL OF MATERIAL

ITEM	DESCRIPTION	MATERIAL	SIZE	NO.

Sandwell Beak Research Group
Centrifugal Separating Machine

					PROJECTION	
					THIRD ANGLE	
					DESIGNED	
					DRAWN LTH	
					CHECKED	
					APPROVED	
		AS DRAWN				
MADE	ISSUE NO.	REVISION	DATE	APPVD	DATE	

CENTRIFUGAL SEPARATOR
SUB-ASSEMBLY

DSMA International Inc.
Engineers and Constructors
Toronto, Canada

SCALE				
FULL SCALE				
PROJECT NO.	SECTION	SIZE	DWG. NO.	ISSUE
4053		E	4053-002	1/0

APPENDIX A

Centrax Specifications

Physical Properties of Processsed Material	
- solids concentration of feed	- 5→20% W/W
- particle size	- 0.1→100 microns
- particle density	- 1.3→2.5 g/cm^3
- solution density	- 0.9→1.1 g/cm^3
- viscosity of liquid phase	- ?
- composition of solids	- coal + ash
- composition of liquid	- low→very high MW oils
- character of 'wet' solids	- abrasive -'sticky'- non flowable
- character of 'dry' solids	- abrasive - non sticky- flowable- dusty
- filterability of solids cake	- non or minimal.
Operating Conditions	
- temperature	- Up to 200°C in one part and up to 600°C in other section
- pressure	- atm
- residence time	- 3—10 s in each stage
- centrifugal force in rotational part of equipment	- 3000 G +
- throughput capacity - slurry feed	- 0.5→4 USGPM
- cake	- 15→400 kg/h
- liquid phase	- 0.3→3.6 USGPM
- condition of discharged solids	- 'bone dry' (0% liquid)
- concentration of 'ash' in liquid overflow	- less than 0.01% W/W
- mixing intensity in stationary part of equipment	- high & low shear
Mechanical Requirements	
- fabrication	- no bearings or seals in contact with slurry - minimum number of parts - parts are to be standard, or machining requirements are to be minimal and non complex
- maintenance	- low
- build-up of process material	- none
- control	- automatic / manual
Type of Apparatus	
- mode of discharge	- liquid & solids continuous
- mode of feed	- continuous
- extraction section:	
- separation parts	- relative high velocity rotating sections to effect separation by centrifugal force
- mixing parts	- stationary sections with high-low shear mixing
- mode of operation	- counter current
- solvent recovery section:	- high temperature continuous film flash evaporation/condensation
Scale-Up	- 13,000 USGPM of slurry feed

Prepared by P.G. Groeneweg
03/20/84

APPENDIX B

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: Sandwell Beck Research Group
6870 Goreway Drive
Mississauga, Ontario
L4V 1L9

DATE: 16th April, 1984.

PRESENT:

P. Groeneweg - SBRG
P. Duggan - DSMA

DISTRIBUTION:

S. L. Hodd - SBRG
P. Groeneweg - SBRG
L. Wilde - DSMA
P. Straznicky - DSMA
C. Balkwill - DSMA
M. Higgins - DSMA
P. Duggan - DSMA
File 4053/B1

DISCUSSIONS	ACTION
1. GENERAL The meeting was held to discuss the required design features of the SBRG centrifugal separating machine. Three individual centrifuges are required to separate and purify the solids and liquid extracted from the input slurry. It was agreed that all three centrifuges will be identical in design and grouped around a central drum containing three separate tank compartments for solvent retention. Solids extracted by a centrifuge assembly will drop directly into the solvent below and extracted liquids will be transferred to the adjacent tank in a counter current process. 2. CENTRIFUGE REVIEW Currently available commercial centrifuge designs were reviewed and these fall into two general categories:	

Minutes of Meeting (Cont'd)
Project 4053
Date: 16th April, 1984

DISCUSSIONS	ACTION

- scroll/decanter style
- pusher/scraper style

The scroll/decanter style incorporates a central screw assembly, rotates about the centrifuge axis and carries the deposited solids down the wall of the centrifuge. Deposited liquid passes through the porous wall of the centrifuge drum for collection. A primary requirement of this system is that the scrolling assembly rotates at a speed slightly above the centrifuge speed.

The pusher/scraper style incorporates a central disc which passes down the centrifuge drum removing solids deposited on the wall or an arm mounted tool which periodically enters the drum to remove solids. It is important that the drum and scraper speeds are synchronized in order to minimize scraper abrasion.

3. CENTRIFUGE REQUIREMENTS

Physical Properties of Processed Material

solid concentration of feed	5 - 20% W/W
particle size	0.1 - 100 μm
particle density	1.3 - 2.5 g/cm^3
solution density	0.9 - 1.1 g/cm^3
viscosity of liquid phase	?
composition of solids	coal + ash
composition of liquid	low - very high MW oils
character of wet solids	abrasive - 'sticky' - non-flowable
character of dry solids	abrasive - non-sticky - flowable - dusty
filterability of solids cake	non-minimal

Minutes of Meeting (Cont'd)
Project 4053
Date: 16th April, 1984

DISCUSSIONS		ACTION
Operating Conditions		
temperature	up to 200°C in one part and up to 600°C in 1 other section	
pressure	atmospheric	
residence time	3-10s in each stage	
centrifugal force in rotational part of equipment	3000 G +	
throughput capacity - slurry feed	0.5-4 USGPM	
- cake	15-400 kg/h	
- liquid phase	0.3-3.6 USGPM	
condition of discharged solids	'bone dry' (0% liquid)	
concentration of 'ash' in liquid overflow	less than 0.01% W/W	
mixing intensity in stationary part of equipment	high and low shear	
Mechanical Requirements		
fabrication	no bearings or seals in contact with slurry minimum number of parts parts are to be standard, or machinery requirements are to be minimal and non-complex	
maintenance	low	
build-up of process material	none	
control	automatic/manual	
Type of Apparatus		
mode of discharge	liquid and solids continuous	
mode of feed	continuous	

Minutes of Meeting (Cont'd)
Project 4053
Date: 16th April, 1984

DISCUSSIONS		ACTION
extraction section:		
separation parts	relative high velocity rotating sections to effect separation by centrifugal force	
mixing parts	stationary sections with high-low-shear mixing	
mode of operation	counter-current	
solvent recovery section	high temperature continuous film flash evaporation/condensation	
Scale-Up	13,000 USGPM of slurry feed	

4. CENTRIFUGE DESIGN

It was agreed that centrifuges will be mounted in a vertical orientation with the slurry entering from below through a 1/2" diameter feed pipe. A drum of 0.4 in diameter was nominally selected to give a particle acceleration of 3000 g at an operating speed of 3000 rpm. This speed would permit the use of a 2 pole direct drive, A.C. motor operating at 3600 rpm if desired. Centrifuged solids will be deposited on the inside surface of the centrifuge drum and the liquid will flow over the surface of the solids. An inward sloping face at the base circumference of the drum will ensure that liquids flow slowly up the drum surface to exit through holes drilled around the drum periphery. A conduit wrapped around the drum will collect this liquid and pipe it to the adjacent tank. Liquid exit holes will be 3/8" diameter and initially six holes will be incorporated. A 1/2" raised platform with a 15° nose shear angle will be used to prevent solids passing through these holes and a 1/8" step on the underside will permit the liquid to be guided into the holes. The lower drum face will slope at an angle of 10° for a length of 4". Drum length will be

Minutes of Meeting (Cont'd)
Project 4053
Date: 16th April, 1984

DISCUSSIONS	ACTION
approximately 0.4 in and the inside surface must be smooth, possibly with an electrically deposited hardened coating to ensure low friction between deposited solids and drum walls. External or internal stiffeners should not be used to structurally reinforce the centrifuge drum as these absorb power and create excessive noise at high rotational speeds. For this reason reinforcing spokes at the lower end of the drum are to be avoided. 5. SCRAPER DESIGN It was agreed that the scroll style centrifuge design will not be pursued. Difficulties could be encountered with deposited solids sticking to the surface of the scroll assembly blades rather than passing down the bowl. In addition, difficulties could be encountered with the transport of liquid through the blades to pass up the bowl surface. Mechanical design problems include the fabrication of a scroll assembly where the blades must be attached to support columns rather than a central support cylinder in order to permit the unrestricted radial movement of centrifuged material. The design approach will be to incorporate a solid disc scraper in the form of a piston which will travel approximately 2" axially down the upper portion of the centrifuge drum. This scraper geometry will maintain a close fit with the drum surface and its action will be to push the deposited solid "sleeve" down the drum with an equivalent 2" deep ring ejected from the drum into the solvent below. The reciprocating action of the scraper assembly will be continuous with one complete cycle in three seconds. A form of "piston ring" will be installed around the sliding surface of the scraper disc in order to deter the passage of solids or liquid to the area behind the scraper. Exit passages will be included in the upper surface of the centrifuge drum to permit the removal of any migrating material. A rotating assembly attached to the underside of the scraper will be used to disperse slurry entering the centrifuge through the feed pipe in a uniform	

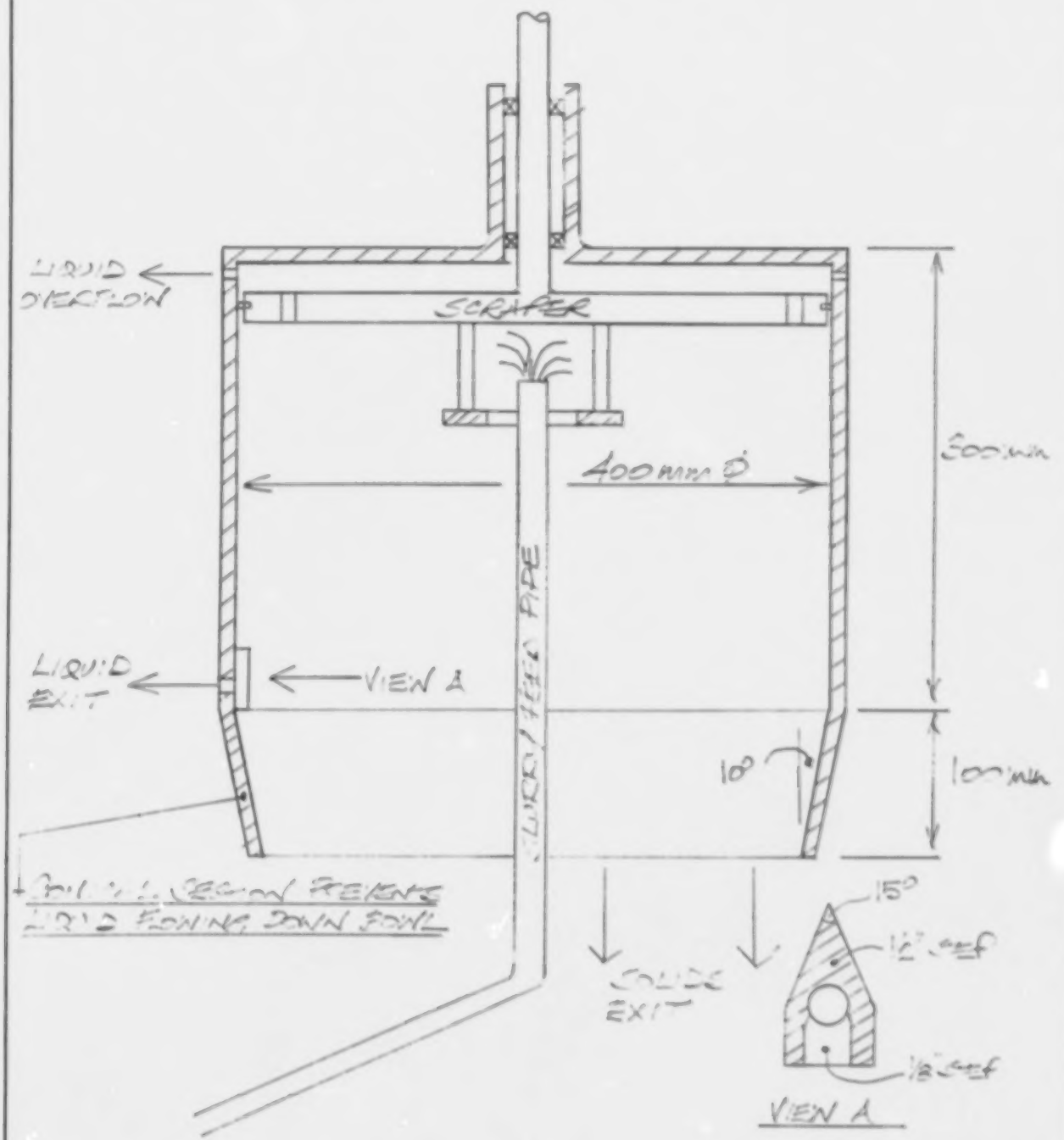
Minutes of Meeting (Cont'd)
Project 4053
Date: April 16th, 1984

DISCUSSIONS	ACTION
manner. This dispersion system will use 12 x 1/2" diameter bars arranged around a 6" diameter support ring. A minimum clearance will be maintained between the feed pipe exit plane and the underside of the scraper assembly. The reciprocating drive system for the scraper assembly will be investigated by DSMA in conjunction with the centrifuge drive assembly.	DSMA
6. TANK REQUIREMENTS The base centrifuge support tank will have three equal sized compartments arranged in a circular form. The outside surface will be circular and the tank diameter will be sized to incorporate the grouped centrifuge assemblies. The solvent surface will lie immediately below the centrifuge drum and liquid depth will be 0.5 metre. A conical surface beneath the centrifuge will direct the removed solids into the solvent and a replaceable wear surface will be considered to handle the abrasive effects of the high speed solids. A mixed assembly mounted to the outside surface of the tank and projecting into the solvent will be used to agitate the mixture. This mixer assembly drive system will be kept clear of the liquid surface to eliminate liquid seal problems. Seals will be designed to withstand hydrocarbon vapours and an internal tank ambient temperature of 180°C. Stainless steel materials will be used where appropriate with alloy steel used for drive shafts and other highly loaded components. The support tank will be insulated externally to maintain a constant tank temperature. SBRG will consider the process requirements and sequencing between the three individual solvent compartments in addition to liquid entry and exit requirements. Slurry feed into the system is estimated at a nomninal 4 USGPM.	SBRG

Minutes of Meeting (Cont'd)
Project 4053
Date: 16th April, 1984

DISCUSSIONS	ACTION
7. DRIVE SYSTEM	
The centrifuge drive system will use a 550 V AC, 3 phase 60HZ supply and the controller cabinet may be wall mounted. Centrifuge acceleration requirements are not rigid but the drive system should be capable of passing quickly through critical speed regimes.	
Steady state speed control requirements will be based upon 3000+/- 600 rpm. Speed accuracy, repeatability and resolution requirements to be recommended by DSMA. Remote control of the drive system is not a requirement. Centrifuges will be accelerated in an unloaded condition and load variations will result from the cyclic removal and introduction of slurry material. A braking system will be required to bring the system rapidly through critical speed zones.	DSMA
Drive system power requirements to be determined by DSMA on the basis of system friction and acceleration requirements.	DSMA
8. GENERAL	
A preliminary schedule for the conceptual design of the system was reviewed and approved. A copy of this schedule is attached.	
Drawings will be in third angle projection. Metric dimensioning will be used if these are appropriate for local equipment manufacture.	DSMA
Next design meeting to be held on 19th April.	

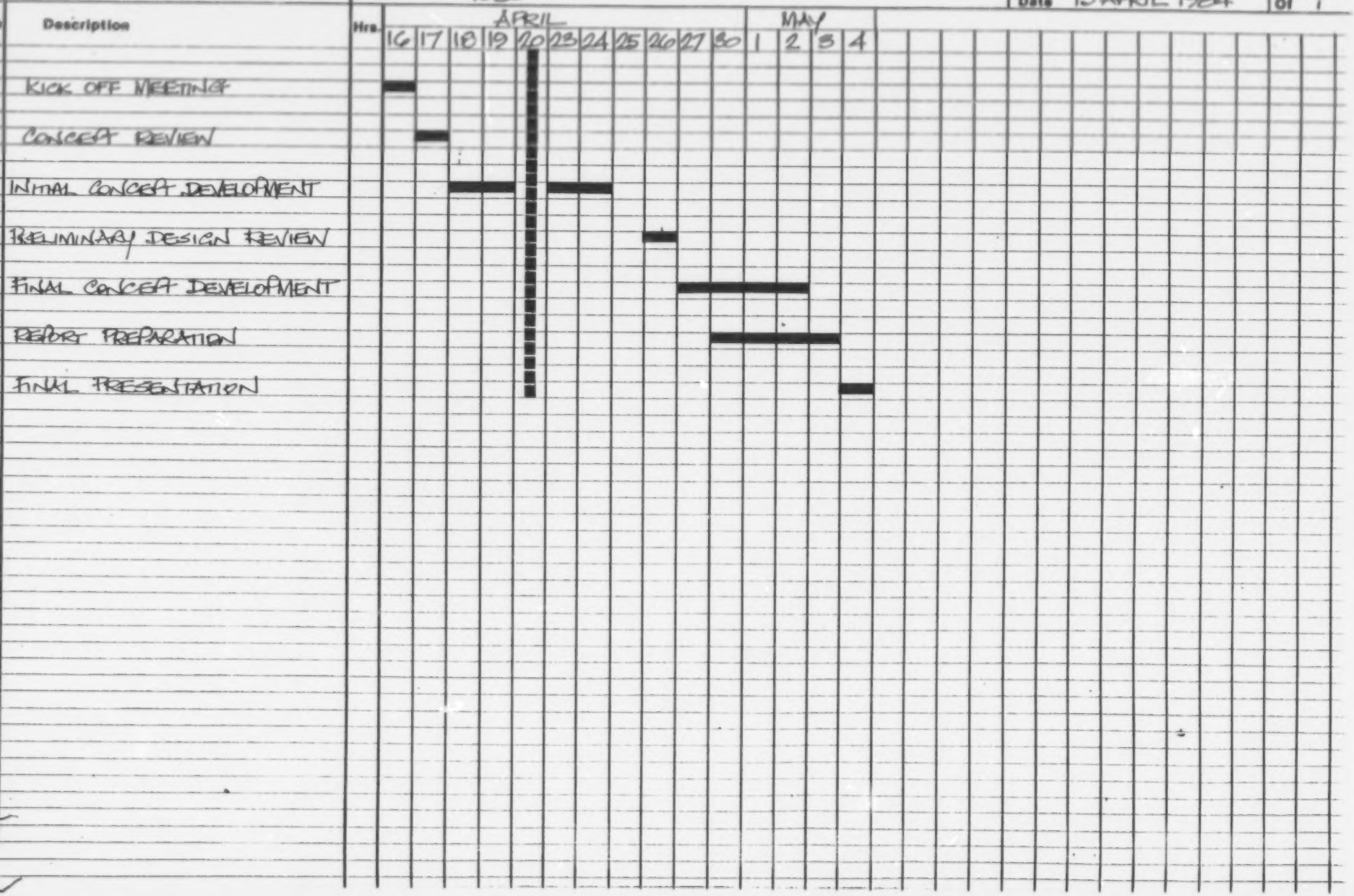
DSMA International Inc. Toronto, Canada	Design Report	
	Project No. 4053	D.R. No.
	By F.D. Date 16-2	Page 1
Subject DEVICE DESIGN	Checked Date	Of 1



DSMA International Inc.
Toronto, Canada

Project Title: CENTRIFUGAL SEPARATING MACHINE
Project No. 4058

FORM
Signed Date: 13 APRIL 1984
Sheet 1 Of 1



MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine
Sandwell Beck Research Group

PLACE: DSMA International Inc.
10 Park Lawn Road
Toronto, Ontario
M8Y 3H8

DATE: 19 April 1984

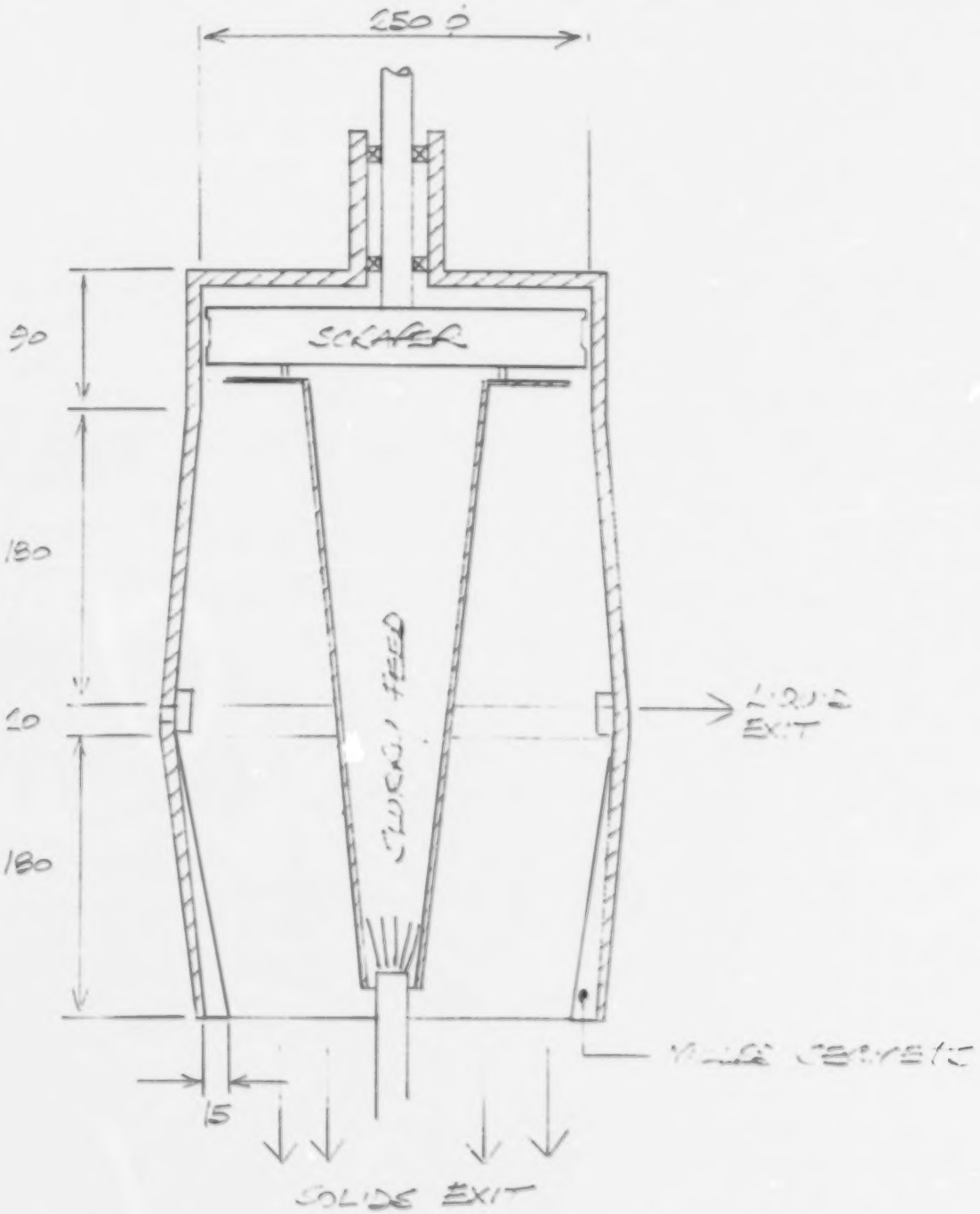
PRESENT: P. Groeneweg - SBRG
P. Duggan - DSMA
M. Higgins - DSMA (Part time)

Distribution: S.L. Hodd - SBRG
P. Groeneweg - SBRG
L. Wilde - DSMA
P. Straznicky - DSMA
C. Balkwill - DSMA
M. Higgins - DSMA
P. Duggan - DSMA
FIle 4053/B1

DISCUSSIONS	ACTION
1. GENERAL The meeting was held to discuss further conceptual design features of the SBRG centrifugal separating machine. Further consideration must be given by SBRG to the process requirements and it was agreed that, at present, attention will be focussed upon the mechanical design of the centrifuge assembly.	SBRG
2. CENTRIFUGE ASSEMBLY Modifications to the centrifuge design were proposed by SBRG in order to ensure that solids can be effectively removed by the scraper assembly. An offset drive system permits the use of higher bowl speeds with variable diameter pulleys. This, in turn, permits a smaller bowl diameter to achieve particle acceleration levels of 3000 g. A bowl diameter of 250 mm was proposed. The upper scraper section will be 30 mm in length, followed by a 180 mm section tapering by 15 mm. Liquid take off points will be installed at the lower end of this tapered section. A 20 mm long vertical section will be followed by a 180 mm long section tapering in to a diameter equivalent to the scraper section. This lower,	

DISCUSSIONS	ACTION
tapered section, will contain segments milled, to a depth of 15 mm in a hexagonal orientation. The design of the bowl will assume a 10 mm thick cake on the inside surface. Gravity feed of slurry to the centrifuges would be preferred to eliminate the requirement for pumps and this would entail staggered vertical locations for the centrifuge assemblies. DSMA agreed to consider the use of a central drive motor controlling the speed of all three centrifuges simultaneously with a staggered pulley arrangement.	DSMA
3. SCRAPER DESIGN A modified scraper design was proposed with a reduced stroke of 20 mm. Stroke will be adjustable up to 30 mm maximum. The scraper design will include a slurry feed system with a conical feed pipe and a distribution disc with radial vanes to accelerate the slurry particles. The feed duct will slope at 15° and the inlet feed pipe must terminate at the lower end of this duct in order to maintain an adequate head between the feed pipe and its supply tank surface. The scraper length will be increased to eliminate the possibility of jamming in the bore of the bowl and extra sealing rings may be incorporated. The extended piston length will reduce the need for the radial support posts. Holes drilled around the circumference of the scraper disc will allow the space behind the disc to breath. All support bearings will be mounted outside the tank cover to avoid exposure to the tank temperature of 180°C.	DSMA
4. MISCELLANEOUS DSMA agreed to consider the incorporation of viewing ports in the tank container wall.	DSMA
DSMA suggested that one prototype centrifuge assembly be built initially for testing, prior to the final production of three models. SBRG agreed to consider this proposal. Next meeting will be held on 23 April at 1:00 p.m.	SBRG

DSMA International Inc. Toronto, Canada	Design Report	
	Project No. 4053	D.R. No.
	By F.D. Date 9.2.82	Page
Subject CENTRIFUGE DESIGN	Checked Date	Of 1



MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine
Sandwell Beck Research Group

PLACE: DSMA International Inc.
10 Park Lawn Road
Toronto, Ontario
M8Y 3H8

DATE: 23 April 1984

PRESENT: P. Groeneweg - SBRG
P. Duggan - DSMA

Distribution: S.L. Hodd - SBRG
P. Groeneweg - SBRG
L. Wilde - DSMA
P. Straznicky - DSMA
C. Balkwill - DSMA
M. Higgins - DSMA
P. Duggan - DSMA
File 4053/B1

DISCUSSIONS	ACTION
1. CENTRIFUGE ASSEMBLY A sketch of the proposed centrifuge assembly drive system was reviewed. Sealing arrangements were not shown and are yet to be developed. Bearings will be moved away from the influence of the tank environment. It was agreed that drum acceleration requirements are not critical but drum deceleration time is important since the drum is carrying the extra mass of the deposited solids. Detail design of the scraper assembly was reviewed and it was agreed that radial spokes will not be incorporated since these would result in uneven solid deposits on the wall of the centrifuge bowl. The slurry inlet pipe will be located as low as possible within the bowl and a conical funnel with a total included angle of 15° will direct slurry to the rotating scraper. The slurry will be radially accelerated by the friction action of two parallel plates.	

DISCUSSIONS	ACTION
The problem of solid particles migrating behind the scraper disc was recognised and methods to relieve this solids build-up will be investigated by DSMA and SBRG.	DSMA/ SBRG
The possibility of installing the centrifuge in an inverted fashion was examined. This has the advantage that incoming slurry is evenly distributed due to gravitational effects. Disadvantages are that the solvent tank must be wrapped around the centrifuge and mixing could be a problem. In addition, creating the necessary pressure head between adjacent tanks could be difficult. SBRG will consider this possibility further prior to the next meeting.	SBRG
DSMA agreed to consider the advantages/disadvantages of a scroll/ decanter style centrifuge when compared with the scraper style.	DSMA
Next meeting will be held at 1:30 p.m. on 24 April.	

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: Sandwell Beck Research Group
6870 Goreway Drive
Mississauga, Ontario
L4V 1L9

DATE: 24 April, 1984

PRESENT: P. Groeneweg - SBRG
P. Duggan - DSMA

Distribution: S.L. Hodd - SBRG
P. Groeneweg - SBRG
P. Straznicky - DSMA
C. Balkwill - DSMA
M. Higgins - DSMA
P. Duggan - DSMA
File 4053/B1

DISCUSSIONS	ACTION
1. CENTRIFUGE ASSEMBLY The preliminary sketch (attached) of the mechanical drive assembly for the centrifuge has been reviewed by SBRG and is considered to be too complicated for the final full size design. SBRG would prefer to use less bearing assemblies and seals and prefer grease lubrication of bearings. DSMA pointed out that bearing oil lubrication is a consequence of high rotational speeds up to 6000 rpm. It was agreed that since the full size equipment will have a larger bowl diameter and correspondingly lower rotational speeds (for 30000 g) the high bowl speed should not be allowed to complicate the mechanical assembly. DSMA agreed to investigate the availability of grease lubricated bearings running at 4600 rpm (for 250 mm bowl diameter). Lip seals are also a problem at the lower end of the assembly due to the corrosive nature of the solvents in the centrifuge tank. It was agreed that a labyrinth type seal would be used in this location with dry nitrogen purging of the cavity between	DSMA

DISCUSSIONS	ACTION
bearings. A lip seal can be used at the upper end of the assembly to prevent nitrogen leakage. No seal will be used between the scraper and drum shafts.	
DSMA will consider the use of self lubricated bushings for linear guidance of the scraper shafts in place of bearing assemblies.	DSMA
The use of a gearbox such as a Cyclo reducer will be considered to drive the reciprocating shaft of the scraper assembly. This would eliminate the requirement for an external reciprocating drive system but the effects on reliability must be considered.	DSMA
2. SCRAPER ASSEMBLY	
SBRG suggests the use of slots in the centrifuge bowl surface to remove solid material which could migrate to the rear of the scraper piston. These should be tapered with an internal diameter of 2 - 3 mm and slots will be required to cover the full circumference. Slots should be located immediately behind the rear face of the scraper piston to ensure the departure of solids.	
Holes should also be provided in the scraper piston to relieve hydrocarbon vapours.	
It was agreed that the 20 mm straight section at the bowl mid-point can be eliminated.	DSMA
Next meeting will be held 26 April at 1:30 p.m.	

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: Sandwell Beck Research Group
6870 Goreway Drive
Mississauga, Ontario
L4V 1L9

DATE: 30th April, 1984.

PRESENT:

P. Groeneweg - SBRG
P. Duggan - DSMA

DISTRIBUTION:

S. L. Hodd - SBRG
P. Groeneweg - SBRG
P. Straznicky - DSMA
C. Balkwill - DSMA
M. Higgins - DSMA
P. Duggan - DSMA
File 4053/B1

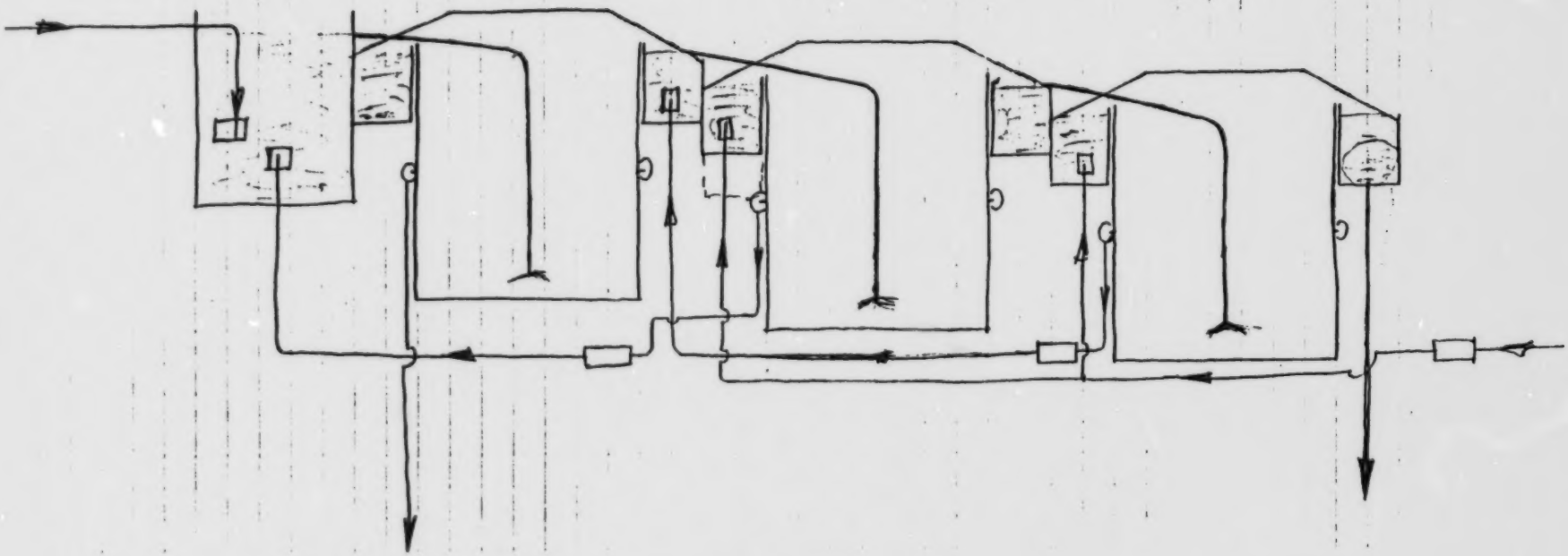
DISCUSSIONS	ACTION
1. BOWL FRICTION DSMA pointed out that the loading on the scraper piston when pushing deposited cake down the bowl can vary significantly and is directly proportional to the assumed coefficient of friction at the interface between cake and bowl. This coefficient can be reduced by polishing of the bowl wall. After reviewing a table of friction coefficient values for several materials and surfaces it was agreed that a value of 0.5 will be used for calculation purposes. Cake density also affects the axial piston loading and the following values were agreed for the cake constituents: 25% at 2.5 g/cm^3 25% at 1.3 g/cm^3 50% at 1.0 g/cm^3	

Minutes of Meeting (Cont'd)
Project 4053
Date: 30th April, 1984

DISCUSSIONS	ACTION
DSMA agreed to calculate the hydraulic actuator size required to handle these loads, assuming a 3000 psi supply and produce a sketch showing the alternative drive arrangement.	DSMA
2. BOWL SIZE To reduce the quantity of deposited cake it was agreed that the 180 mm section lengths will be reduced to 100 mm and the 20 mm straight section will be eliminated. The taper angles will change to retain the 15 mm radial extension.	DSMA
3. BOWL ORIENTATION In order to improve the slurry feed arrangement it was agreed that the centrifuges will be inverted. This would eliminate the requirement for the tapered slurry feed section, since an inverted arrangement allows for easy control of pressure heads from adjacent solvent tanks. The final centrifuge would require a method to remove cake material in a continuous process. DSMA/SBRG to consider possible arrangements. SBRG confirmed that the direction of bowl rotation is not important.	
4. TANK ARRANGEMENT Two inverted centrifuges will be arranged with "wrap around" solvent tanks with an annular radius of 75 mm. Overall tank depth will be 100 mm based upon liquid exit point location. The interface between centrifuge bowl and surrounding tank will be designed to minimize spillage to the container below. The third centrifuge will incorporate a solids collection device around its circumference. "Eductors" will be used, attached to the end of feed pipes, to ensure continuous motion of tank solvents, and 1/2" diameter stainless steel tube will be used throughout.	

Minutes of Meeting (Cont'd)
Project 4053
Date: 30th April, 1984

DISCUSSIONS	ACTION
The two circulation pumps required will be installed within the centrifuge container vessel with external drives. The possible use of hydraulic rotary actuators which can be installed within the environment of the container will be investigated.	SBRG/DSMA
The 600°C process unit will be eliminated at this time.	
A sketch of the proposed process arrangement is attached.	
Next meeting to be held 2nd May at 1.30 p.m. in DSMA offices.	



PROPOSED CENTRIFUGE ARRANGEMENT

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine
Sandwell Beck Research Group

PLACE: DSMA International Inc.
10 Park Lawn Road
Toronto, Ontario
M8Y 3H8

DATE: 2 May 1984

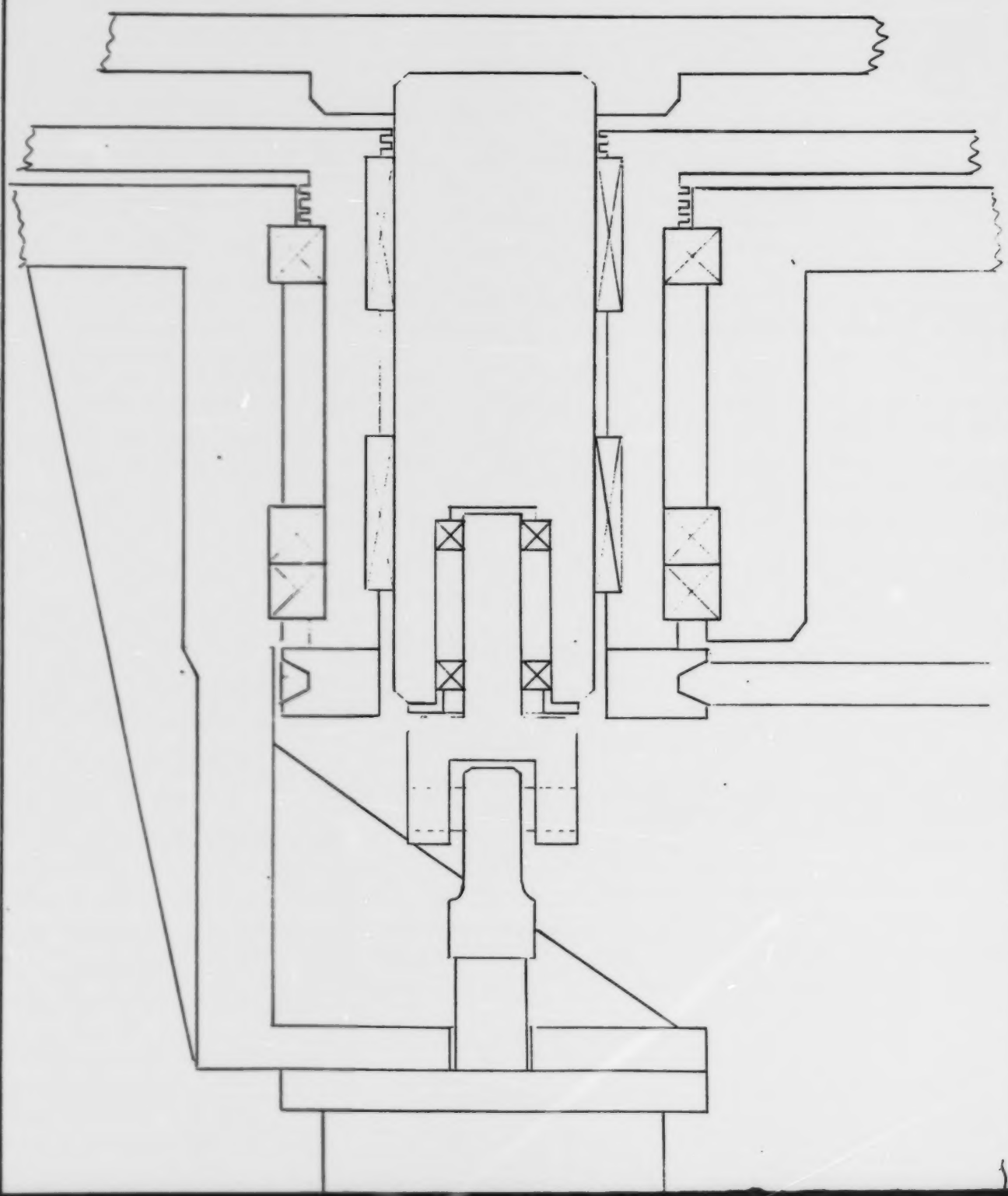
PRESENT: P. Groeneweg - SBRG
P. Duggan - DSMA

Distribution: S.L. Hodd - SBRG
P. Groeneweg - SBRG
P. Straznicky - DSMA
C. Balkwill - DSMA
M. Higgins - DSMA
P. Duggan - DSMA
File 4053/B1

DISCUSSIONS	ACTION
1. CENTRIFUGE ASSEMBLY The revised sketch of the centrifuge drive assembly incorporating a hydraulically actuated scraper drive was reviewed and several design modifications were agreed. The lower support bearing will be relocated to a position 1" higher in order to avoid the temperature effects of the centrifuge bowl. Stiffeners will be included ¼" high, on the rear side of the centrifuge support plate in order to disperse dry nitrogen purging through the drive assembly. A lip seal will be used to prevent nitrogen leaking at the upper bearing interface. A hub will be included on the inside face of the bowl support plate to prevent liquid leaking into the drive bearings.	

DISCUSSIONS	ACTION
A dry nitrogen flow at 10 psi supply pressure should be assumed for labyrinth seal design. Nitrogen will be purged between scraper and bowl drive shafts.	
The centrifuge bowl will be easily removable in the event that bowl geometry changes are required.	
2. TANK ARRANGEMENT	
A system to collect solids from the final centrifuge must be devised. A static hopper design which directs solid materials to a receiver below for oven drying is preferred.	
Dimensions of the receiver to be supplied by SBRG.	SBRG
Solvent tanks surrounding centrifuge bowls will have an inside lid to prevent liquid splashing into the gap between the tank and the centrifuge bowl.	
Dimensions of solvent holding tanks to be confirmed by SBRG.	SBRG
Individual tanks to be staggered by a minimum of 1" or the dimension required to stagger pulleys on the central drive shaft.	
SBRG will determine the style of pumps required within the System.	SBRG
The container vessel will be insulated and heated externally to create an internal temperature of 180°C.	
3. GENERAL	
The final report should include estimates for hardware/manufacture and detailed engineering.	DSMA
A schedule of 4 - 5 months is the aim of SBRG to complete the initial pilot units.	
Next meeting will be held on 4 May at 1:30 p.m.	

DSMA International Inc. Toronto, Canada	Design Report	
	Project No.	D.R. No.
	By Date	Page
Subject	Checked Date	Of



MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine
Sandwell Beck Research Group

PLACE: DSMA International Inc.
10 Park Lawn Road
Toronto, Ontario
M8Y 3H8

DATE: 4th May, 1984.

PRESENT:

P. Groeneweg - SBRG
P. Duggan - DSMA

DISTRIBUTION:

S. L. Hodd - SBRG
P. Groeneweg - SBRG
P. Straznicky - DSMA
C. Balkwill - DSMA
M. Higgins - DSMA
P. Duggan - DSMA
File 4053/B1

DISCUSSIONS	ACTION
1. CENTRIFUGE ASSEMBLY	
A revised sketch of the centrifuge drive assembly was reviewed and several additional design features were agreed.	
The possibility of using a metal sealing ring between the scraper and bowl shafts will be investigated by DSMA.	DSMA
The nitrogen purge system will be incorporated between the scraper and bowl shafts.	DSMA
Liquid take-off point dam design was reviewed and it was agreed that the projecting profile will be designed as slender as possible without a stepped surface at the rear. The intention is that solids may slide easily past this profile and liquids will flow without restriction through a slot in the upper surface. Liquid dams will be located centrally on the non-milled sections of the centrifuge bowl.	

Minutes of Meeting (Cont'd)
Project 4053
Date: 4th May, 1984

DISCUSSIONS	ACTION
2. TANK ARRANGEMENT Turbine style stirrers will be added to the solvent tanks around the centrifuge bowls. These will be angled at 60°C and positioned immediately downstream of the eductor inlets. Centrifuge direction of rotation should coincide with mixer rotation to ensure that ejected solids are not opposing solvent flow. Stirrers should be variable speed. The two pumps required to circulate liquids around the vessel are to be double headed gear pumps with two inputs and two discharge ports. Variable speed motors are required. SBRG to specify model types at a later date. Suction tubes into pump are to be 1/2" diameter and discharge tubes are 3/8" diameter. Accommodation for the initial slurry tank will be designed to accept a full centrifuge unit at a later date in place of the tank. The drive system will be designed to operate four centrifuge assemblies simultaneously. The single slurry feed vessel will be 150 mm deep and 150 mm diameter. Solids will be deposited directly into a hopper from the last centrifuge and dropped into a collector vessel for drying in an oven. Collector vessel dimensions are 500 mm diameter x 737 mm long, in a semi-circular form. Glass viewing portholes are desirable in the covers above the centrifuge bowls. These would require suitable seals at the glass/steel interface. DSMA to investigate.	DSMA

SANDWELL BEAK RESEARCH GROUP

Centrifugal Separating Machine

Interim Development Report

Report Number : 4053/R114

July 1984

Copy Number :

DSMA International Inc.
Toronto, Canada

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FIGURES

DRAWINGS

APPENDIX A - Minutes of Meeting

APPENDIX B - Potential Fabricators

1. INTRODUCTION

This interim report is submitted by DSMA International to Sandwell Beak Research Group as an update to the information contained in DSMA Concept Development Report (4053/R105) issued in May 1984.

During detail design of the Centrifugal Separating Machine a modification to the initial design concept became necessary and a decision was made to reduce the scale of the containment vessel arrangement for the initial pilot plant operation.

In addition, detailed discussions between SBRG and DSMA regarding electrical/controls installation requirements indicated that reductions could be made in the DSMA engineering effort originally estimated.

The scope of this interim report is to

- review conceptual design changes
- describe the current centrifugal separator design philosophy
- develop revised engineering cost and schedule information for detailed engineering required to complete the design of the pilot separating machine
- develop revised hardware cost and schedule information for the manufacture of the pilot separating machine.

Design concept revisions were discussed at several design review meetings between SBRG and DSMA. The minutes of these meetings which form an integral part of this document are attached as Appendix A. A list of potential fabricators of the equipment is listed in Appendix B.

2. CONCEPT DESIGN REVISIONS

The original Concept Development Report (R105) issued in May 1984, described a conceptual design for a Centrifugal Separator assembly which employed a limited stroke scraper piston operating within a shaped separator bowl. The principle behind this arrangement was that the solid nature of the centrifuged cake would permit it to be ejected from the bowl in the form of a sleeve propelled from the lower end by the piston.

Three individual separator assemblies were grouped within a containment vessel and rotated by a common drive motor. Processed material in the form of centrifuged solids and liquid were transferred between the individual separator assemblies with dry solids exiting from the final separator unit.

2.1 Separator Bowl

Following the development of the original separator concept outlined in Report R105 tests were conducted by SBRG to verify that the deposited solid cake did in fact, have the inherent strength required to allow it to be forced out of the bowl as a sleeve by a scraper piston pushing from below.

The SBRG tests revealed that the consistency of the centrifuged cake obtained at various stages of the separation process varied considerably. Cake separated at an early process stage is a non-flowable liquid with a putty-like consistency at the elevated process temperature and a very rigid form at ambient temperature. Cake separated at a later process stage proved to be brittle with high compressive strength but low tensile strength.

SBRG concluded from these experiments that in both the early and late stages of the process the proposed separator design would not be capable of pushing the cake up the bowl in the desired manner, since the piston stroke was limited and relied upon the strength of the cake to propel itself up the bowl.

As a result of these tests, SBRG suggested that the bowl be redesigned and the piston stroke extended to ensure that the centrifuged cake is pushed completely out of the bowl. This design modification resulted in extensive changes to the mechanical drive assembly and relocation of the liquid take-off ports to the upper edge of the bowl.

DSMA reviewed these requirements and concluded that the scraper piston propulsion system could not be resized to produce the stroke extension required. In addition, analysis carried out by SKF Canada had shown that the heavily loaded piston thrust bearings and drive assembly support bearings would have limited life due to the high operational speed of rotation.

For these reasons, a new design approach for the separator drive assembly was developed and the revised design concept is presented in this report.

2.2 Containment Vessel

The containment vessel approach outlined in the Concept Development Report incorporated three separator assemblies with space for a future fourth assembly.

During subsequent discussions, it was agreed that for the pilot system a more economical and low risk approach would be to develop a single containment vessel versatile enough to check out the

various stages of the centrifuge process from the early liquid consistency to the ejection of bone dry solid cake. This is achieved by the incorporation of a solids collection hopper and solvent trough within a single containment vessel. A deflector shield arrangement mounted to the underside of the vessel cover directs the ejected solids to the appropriate receiver.

3. EQUIPMENT DESCRIPTION

The revised design for the Centrifugal Separating Machine is shown on drawings E4053-004 and E4053-005.

The arrangement shown employs a single separator assembly housed in a reduced size containment vessel with the flexibility to eject centrifuged solids into a surrounding solvent tank or solids collection hopper. The separator assembly is driven at the operational speed by a D.C. drive motor via a toothed belt and pulley arrangement.

3.1 Separator Bowl

The 250 mm diameter, straight sided, separator bowl is supported by a bearing assembly and rotated at 4600 RPM to achieve the 3000 g acceleration level necessary for particle separation. The shape of the bowl has been revised to permit the scraper piston to travel its complete length in order to completely remove centrifuged cake. Liquid take-off ports have been relocated to the upper edge of the bowl, outside the scraper extent of travel.

A contoured surface around the upper edge provides a smooth exit for the cake but prevents the passage of liquid. A "plough separator" contour around the liquid exit port is designed to prevent the blockage of the liquid ports by solids cake without impeding the flow of centrifuged liquid. Drain holes are provided in the base of the separator bowl to prevent liquid build-up when the centrifuge is brought to rest.

3.2 Scraper Assembly

The scraper piston, actuated by a rotating hydraulic cylinder, travels the entire length of the bowl to remove centrifuged cake in its path. A hardened ring, bolted to the circumference of the piston is designed for easy replacement when necessary. A minimal gap is maintained between this ring and the bowl surface to limit the migration of solid particles behind the scraper piston and a tapered surface behind the piston prevents the inward passage of these particles during bowl rotation.

The upper face of the scraper piston is contoured to permit the maximum entry length for the slurry feed pipe with the piston in the upper position. Holes through the piston ensure the venting of the lower portion of the bowl during scraper operation.

3.3 Bowl/Scraper Drive System

Actuation of the scraper is achieved by a piston operating within a hydraulic cylinder and connected to the scraper by a piston rod. The hydraulic cylinder, which acts as the support for the separator bowl rotates at the same speed as the bowl and the scraper. The scraper drive components are sized for a hydraulic system pressure of 2000 psi although this pressure will be reduced if scraper loads prove to be lower than anticipated. Piston rod gland seals prevent the leakage of oil into the separator bowl and metal scraper rings isolate the hydraulic seals from the hot corrosive environment of the containment vessel. Scraper piston movement is limited by end stops within the hydraulic cylinder and oil is transferred to the appropriate side of the piston by ports drilled through

the cylinder wall. Hydraulic oil is carried to the rotating cylinder by a dual channel rotary joint bolted to the underside of the cylinder assembly and restrained by the oil inlet and outlet piping. An external hydraulic power pack includes control valves to direct oil to the appropriate cylinder ports at the desired pressure. Rotation of the separator bowl is achieved by a DC drive motor driving a pulley through a toothed belt arrangement.

3.4 Containment Vessel

The reduced scale containment vessel consists of a circular tank into which the separator assembly is mounted. Centrifuged solids can be diverted to either the dry solids hopper or the surrounding solvent tank by removing and replacing the conical deflector shield mounted above the separator bowl. The upper cover of the containment vessel can be easily removed to achieve this transfer. Observation windows are mounted in the containment vessel cover and a proximity sensor is used to detect the position of the scraper piston within the separator bowl. The dry solids hopper consists of a smooth surface trough surrounding the separator bowl into which centrifuged cake is deflected. The high tangential exit velocity of the centrifuged cake provides the momentum required to carry the cake around the trough and down a transfer conduit which passes through the solvent trough to terminate at the outside wall of the vessel.

4. COST ESTIMATES

The estimates included in the Concept Development Report have been revised to reflect the design modifications to the Separator sub assembly and the Containment vessel.

4.1 Hardware Estimate

The following are budgetary cost estimates for the procurement, fabrication and assembly of the hardware required to produce a fully operational Centrifugal Separating Machine to meet SBRG requirements. These estimates do not include the cost of mechanical or electrical installation of the system at SBRG premises since this work may be carried out by SBRG support staff.

a) Separator Sub Assembly

Separator bowl, liquid take off ports, scraper piston, hydraulic cylinder, piston rod, hydraulic piston, bearing assemblies, drive housing, labyrinth seals, piston ring seals, rod wiper seals drive pulley, dual channel hydraulic rotary joint, lip seals, assembly and balancing	$ 13,252

b) Containment Vessel

Tank weldment, support frame, lid assembly, D.C. drive system, stirrer, vibration isolation mounts, pulley/drive belt, pulley shaft, piston position sensor, piping/ fittings, thermal insulation, tank heaters,

hydraulic power pack, scraper control panel, hydraulic control valves, power distribution system and mechanical assembly	$ 28,432
TOTAL ESTIMATED HARDWARE COST	$ 41,684

4.2 Engineering Services

This estimate for engineering services to be supplied by DSMA for the detail design of the Centrifugal Separating Machine includes detailed engineering, preparation of shop drawings and schematics and the preparation of technical specifications in a form suitable for inclusion in a tender document.

Revised estimates for electrical/controls engineering work reflect a transfer of responsibilities for portions of the design work from DSMA to SBRG staff.

The following estimate is broken down on a sub assembly basis.

1. Separator Sub Assembly

Design Draughting

	Drawings	Est. Hours	Est. Cost
Separator Assembly	1	60	3075
Bowl Details	1	60	3075
Scraper Details	1	60	3075
Drive System Details	1	60	3075
Hydraulic Schematic	1	40	2050
	5	280	14350

Engineering Design

	Est. Hours	Est. Cost
Separator assembly configuration including interface requirements bearing selection, seal selection and review of thermal insulation techniques	50	2898
Bowl design including stress/ deformation calculations, rotating inertia calculations, liquid exit port design, and surface finish requirements	50	2898
Scraper design including piston stress/deflection calculations, due to loading and thermal effects, piston seal selection and inertia calculations	50	2898
Drive system design including bearing fits, hydraulic cylinder design, lubrication requirements, critical speed calculations, labyrinth seal design, drive pulley belt selection and selection of dual channel hydraulic rotary joint	50	2898
Selection of hydraulic control components, design of power pack and pipe sizing	50	2853

Write mechanical specification, Select mechanical contractors	30	1658
	280	16103
Estimated Expenses		550
TOTAL		$ 31003

2. Containment Vessel Assembly

Design Draghting

	Drawings	Est. Hours	Est. Cost
Vessel Assembly	1	60	3075
Tank Details	1	60	3075
Lid Details	1	60	3075
Support Frame Details	1	60	3075
	4	240	12300

Engineering Design

	Est. Hours	Est. Cost
Vessel design including interface configuration with separator assembly, solvent trough, solids hopper and drive system	50	2898
Tank design including stress/ deformation calculations, stiffener selection and material selection	50	2898
Lid design including piston location sensor selection solids deflector plate design	50	2898

Frame design including stress calculations, motor support and selection of vibration isolators	50	2898
	200	11592
Estimated Expenses		100
TOTAL		$ 23992

3. Electrical/Controls

Selection and sizing of drive components including drive motor/ controller	30	2337
Specification of hydraulic power pack components and connection requirements	45	2907
Scraper control circuit including logic design, power supply selection and control hardware definition	75	4255
Preparation of detailed technical specification for control system	30	2337
	180	11836
Estimated Expenses		150
TOTAL		11986
TOTAL ENGINEERING ESTIMATE		$ 66981

4.3 Schedule

Figure 1 shows the proposed schedule for the completion of the detail design, fabrication, and assembly of the Centrifugal Separating Machine. This schedule is based upon the use of outside mechanical contractors with electrical installation work by SBRG personnel.

Some schedule improvements may be feasible by phasing the fabrication of the separator sub assembly and containment vessel, as soon as detail design drawings have been completed.

Further schedule improvements may also be possible by early discussions with potential fabricators and close monitoring of the selected suppliers.

FIGURES

DSMA International Inc.

Toronto, Canada

Project : Sandwell Beak Centrifugal Separating Machine Schedule

Project No.: 4053

Figure 1.

Date: July 1984

Item	July				August					September				October				November					December			
	6	13	20	27	3	10	17	24	31	7	14	21	28	5	12	19	26	2	9	16	23	30	7	14	21	28
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
1. Separator Assembly Design																										
2. Containment Vessel Design																										
3. Electrical/Controls Design																										
4. Tender Document Preparation																										
5. Manufacturer Sourcing																										
6. Tender/Bid Evaluation																										
7. Equipment Fabrication																										
8. Equipment Assembly																										
9. Install Electrical System																										
10. Commissioning																										

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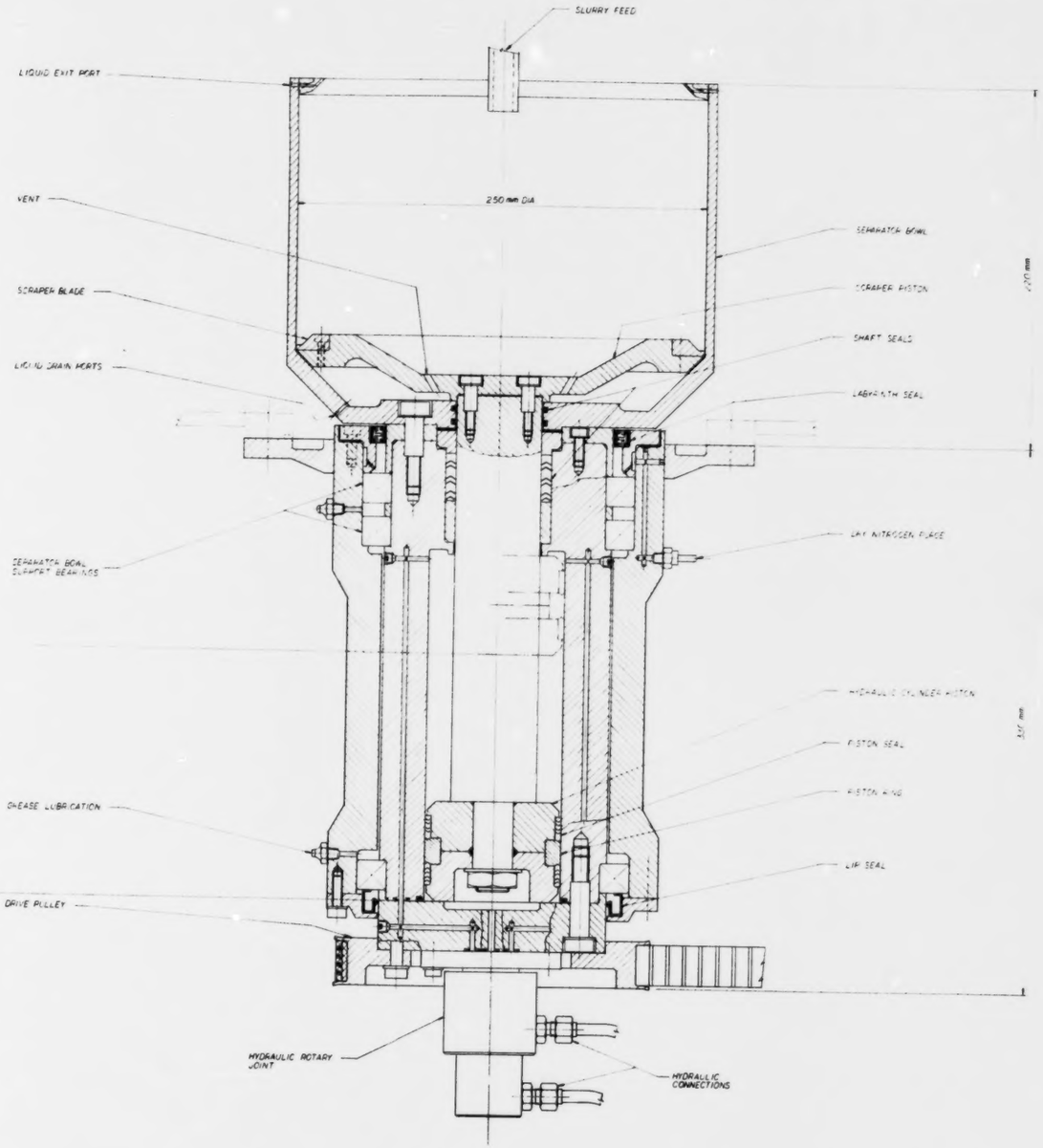
DRAWINGS



DWG. NO.	REFERENCE DWGS.

BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	MATERIAL	NOTE	WT

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SW	AS DRAWN			
ISSUE	DATE	REVISION	DATE	APPROVED

PROJECTION: THIRD ANGLE
DESIGNED
DRAWN SW
CHECKED
APPROVED

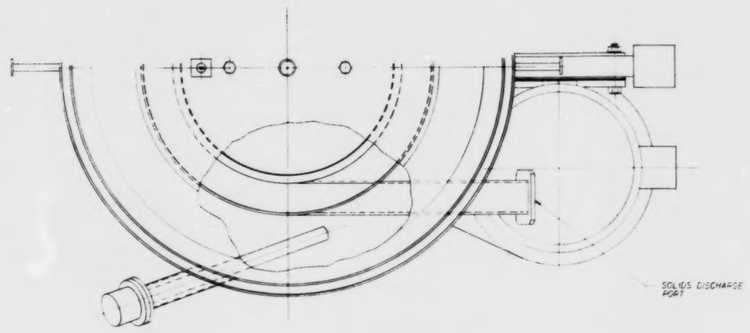
CENTRIFUGAL SEPARATOR
SUB-ASSEMBLY
CONCEPT II

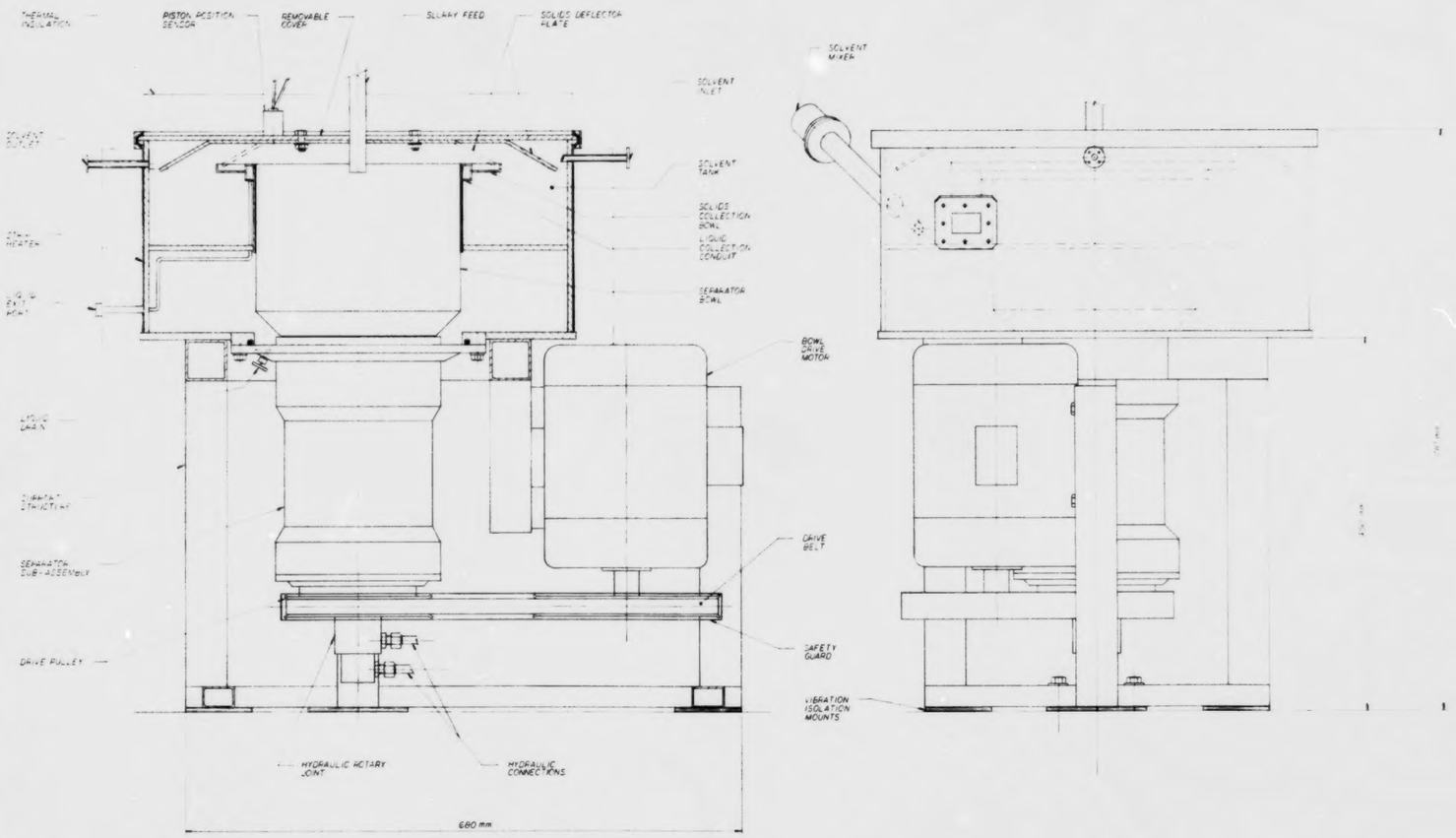
Sandwell Beak Research Group
Centrifugal Separating Machine

DSMA International Inc.
Engineers and Constructors
Toronto, Canada

SCALE	SHEET	SHEETS
FULL SIZE	1 OF 1	
PROJECT 4053	SECTION	SIZE E
DWG NO. 4053-004	ISSUE	

E 4083-005





DWG. NO.	REFERENCE DWGS.

BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	MATERIAL	NOTE	WT

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				PROJECTION	
				THIRD ANGLE	
				DESIGNED	
				DRAWN SW	
				CHECKED	
				APPROVED	
SW	AS DRAWN	REVISION	DATE	APPD	DATE

CENTRIFUGAL SEPARATOR ARRANGEMENT CONCEPT II

Sandwell Beak Research Group
Centrifugal Separating Machine

DSMA International Inc.
Engineers and Constructors
Toronto, Canada

SCALE HALF	SIZE	SHEET	OF	SHEETS
PROJECT 4083	SECTION	SIZE E	DWG. NO. 4083-005	ISSUE

APPENDIX A

MINUTES OF MEETINGS

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: Sandwell Beak Research Group
6870 Goreway Drive
Mississauga, Ontario
L4V 1L9

DATE: 25 May, 1984

PRESENT: P. Groeneweg
P. Duggan - DSMA

Distribution: S.L. Hodd - SBRG
P. Groeneweg - SBRG
P. Straznicky - DSMA
C. Balkwill - DSMA
M. Higgins - DSMA
P. Duggan - DSMA
File 4053/B1

DISCUSSIONS	ACTION
1. General The concept development report for the Centrifugal Separating Machine has been completed and was delivered to SBRG on 14 May, 1984. The purpose of this meeting was to review the mechanical design of the separator assembly and containment vessel in order to incorporate design changes and improvements. Another meeting will be scheduled next week to review contractual matters. 2. Containment Vessel SBRG have decided to proceed with the design of a single separator housed in a smaller multifunctional single stage unit. This single stage unit must be capable of simulating both solids discharge into a collection hopper and into a solvent tank.	

DISCUSSIONS	ACTION
SBRG suggests the incorporation of a moveable deflector plate which can be deployed when dry solids removal is required. The deployment of this deflector plate must be from outside the vessel to avoid removing the cover. It may be more appropriate to locate the solvent tank on the outside wall with the deflector plate deployed to remove solids directly. DSMA agreed to investigate the advantages/disadvantages of these options.	DSMA
Liquid discharge will be to an external tank via a pump installed inside the containment vessel with the option of gravity feed if required. A level control to be specified by SBRG will be used to control the flow of liquid through this pump.	
The size of the observation window in the cover of the containment vessel will remain unchanged.	
The liquid collection conduit around the separator bowl should be altered to ensure that liquid will not splash back through the entry slot. This can be achieved using a rectangular conduit with a sloping rear face and a lip attached to the entry slots. DSMA agreed to review alternative schemes.	DSMA
3. Separator Assembly	
SBRG suggested an alternative design for the bowl shear plates to improve the break up of cake moving up the bowl surface. This would consist of segments cut from a tapered annular ring which are bolted to the circular bowl surface with a diverging machined edge to ensure that cake is not compacted. DSMA suggested that a step may be required at the leading edge to avoid a wafer-thin face and prevent erosion but agreed to investigate further.	DSMA
SBRG queried the removal procedure for the toothed drive belt. DSMA agree that this is awkward since the actuator support fixture must be detached prior to belt removal but since belt replacement will be infrequent this may not prove to be a problem.	
DSMA agreed to review the design of the scraper piston thrust bearings in an attempt to produce a more compact assembly package but pointed out that this may not be possible due to the high axial scraper loading.	DSMA
The selection of a spline to handle axial scraper movement was reviewed and it was agreed that this represents the most compact method of incorporating axial and rotational motion to the scraper.	

:mw

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: Sandwell Beak Research Group
6870 Goreway Drive
Mississauga, Ontario
L4V 1L9

DATE: 30 May 1984

PRESENT: P. Groeneweg
P. Duggan - DSMA

Distribution:

S.L. Hodd - SBRG
P. Groeneweg - SBRG
L. Wilde - DSMA
P. Straznicky - DSMA
C. Balkwill - DSMA
M. Higgins - DSMA
P. Duggan - DSMA
File: 4053/B1

DISCUSSIONS	ACTION
1. GENERAL The meeting was held to discuss the conceptual design of the multifunctional single stage containment vessel. It has been agreed that the containment vessel design will be modified to accommodate a single separator sub assembly only and permit operation by discharge of centrifugal solids into a solvent tank or directly into a collection hopper. 2. CONTAINMENT VESSEL Several approaches to the design of a single stage vessel were discussed and for several reasons it was agreed that the dry solids collection ring should be located inboard of the annular solvent tank. This will ensure that solid particles released from the separator bowl will retain their momentum in the tangential direction encouraging them to slide through the exit port, down the transfer conduit and out of the containment vessel.	

DISCUSSIONS	ACTION
The transfer conduit creates a problem since it must cross the annular solvent tank to reach the outside wall. An exposed conduit will permit the deposition of solids on the upper surface. It was agreed that this conduit will be submerged in the solvent for at least 2/3 of its route across the solvent tank.	DSMA
A deflector ring will be required which can be manually raised or lowered from outside the containment vessel in order to deflect centrifuged solids either into the solvent tank or into the collection hopper. This deflector ring should not obscure the observation window and simple clamps can be used to lock it in position.	DSMA
The liquid collection conduit should be of a rectangular cross-section with an aspect ratio of approximately 2/1 in order to prevent splash-back of centrifuged liquids, with one suitably positioned take-off pipe.	DSMA
3. MISCELLANEOUS	
An estimate of budget requirements to further the design to the detailed engineering phase was forwarded to SBRG and will be reviewed before the next meeting.	SBRG
The next design review meeting will be held on 1 June at 1:30 p.m.	

:am

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: Sandwell Beak Research Group
6870 Goreway Drive
Mississauga, Ontario
L4V 1L9

DATE: 1st June, 1984.

PRESENT:

P. Groeneweg - SBRG
P. Duggan - DSMA

DISTRIBUTION:

S. L. Hodd - SBRG
P. Groeneweg - SBRG
L. Wilde - DSMA
P. Straznicky - DSMA
C. Balkwill - DSMA
M. Higgins - DSMA
P. Duggan - DSMA
File 4053/B1

DISCUSSIONS	ACTION
1. GENERAL SBRG handed over a letter authorizing DSMA to proceed with the next phase of the Centrax Hardware Development. The intent of this phase is to review the design in more detail in order to identify long lead components or difficult design areas and to further the concept to a point where detail drawings can be started. 2. CONTAINMENT VESSEL An initial sketch of the single stage containment vessel was reviewed and several design changes agreed. Since the slurry feed pipe must enter the centrifuge bowl on axis it was agreed that the large central viewing window should be replaced by three smaller windows with the slurry pipe penetrating the cover on centre.	

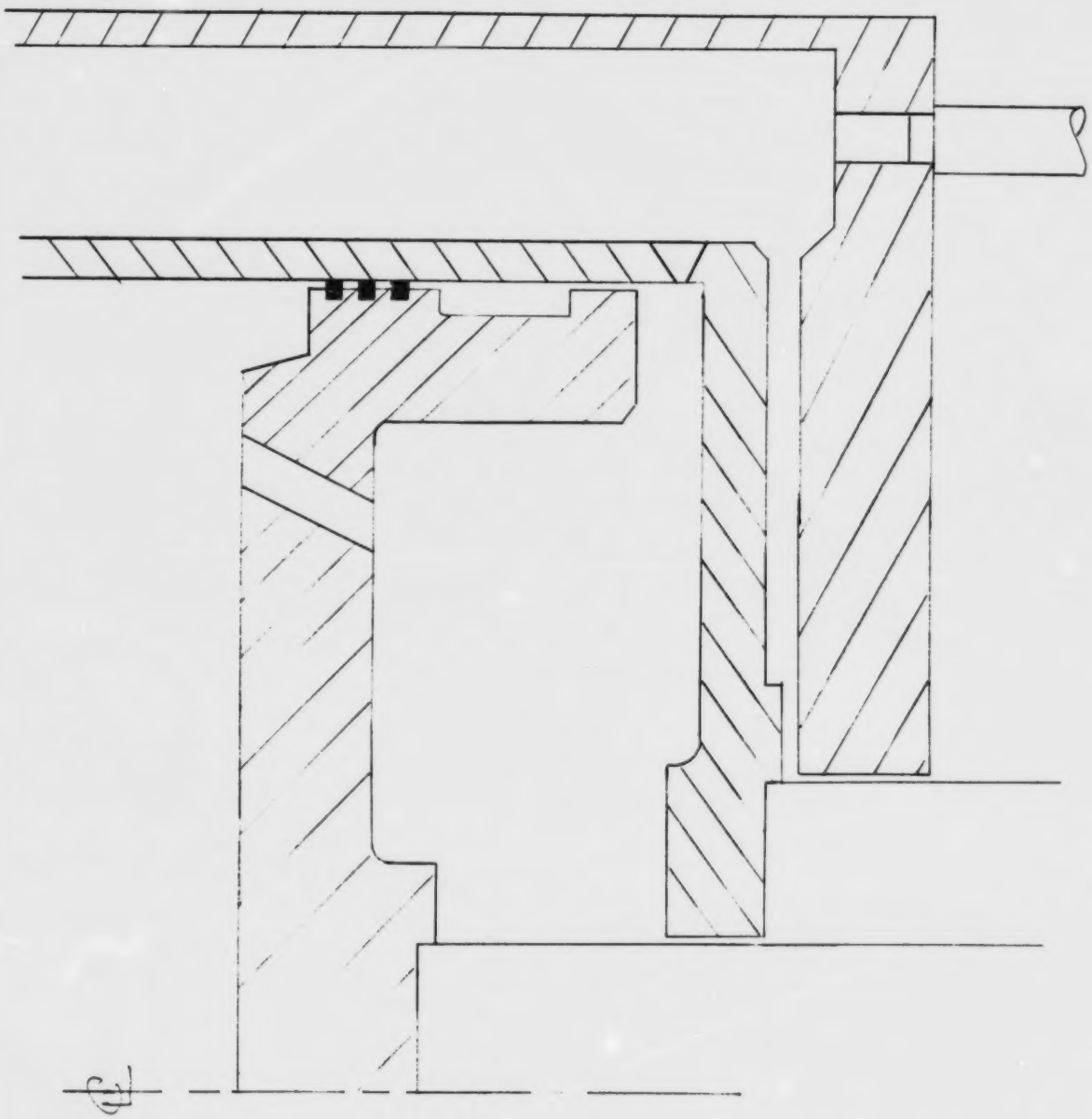
Minutes of Meeting (Cont'd)
Project
Date: June 1st, 1984

DISCUSSIONS	ACTION
A slurry feed pipe interface will be provided adjacent to the windows so that the feed pipe may be removed with the cover.	DSMA
A Marman style band clamp will be used to hold the top cover in place permitting easy removal, with an asbestos style gasket acting as a seal.	DSMA
The solids only collection bowl will lie adjacent to the separator bowl with the transfer conduit exiting through the solvent bowl at an angle of 15° and tangentially to the bowl surface. The transfer conduit will be rectangular in cross section with a flanged connection at the outside wall of the vessel.	DSMA
The deflector ring required to divert centrifuged solids into the inner bowl will be bolted to the underside of the top cover and will not require position adjustment from outside the vessel. When a system configuration change is required the procedure will be to remove the top cover and attach or detach the deflector ring assembly. The inner diameter of this ring will not project beyond the inside wall of the collection bowl to prevent solids passing through the gap between this bowl and the separator bowl.	DSMA
The pump required to control centrifuged liquid flow will now be mounted external to the containment vessel.	
Band and strip heaters mounted on the outside surface of the vessel will be used to maintain process temperature.	
3. SEPARATOR SUB-ASSEMBLY	
The conceptual design drawing of the Separator Sub-Assembly was reviewed and several design changes proposed by SBRG.	
Since the recently deposited wet cake may be too compressible, a piston contour change is proposed with a depressed section at the outer edge for an annular distance of 10 mm with a 15°	

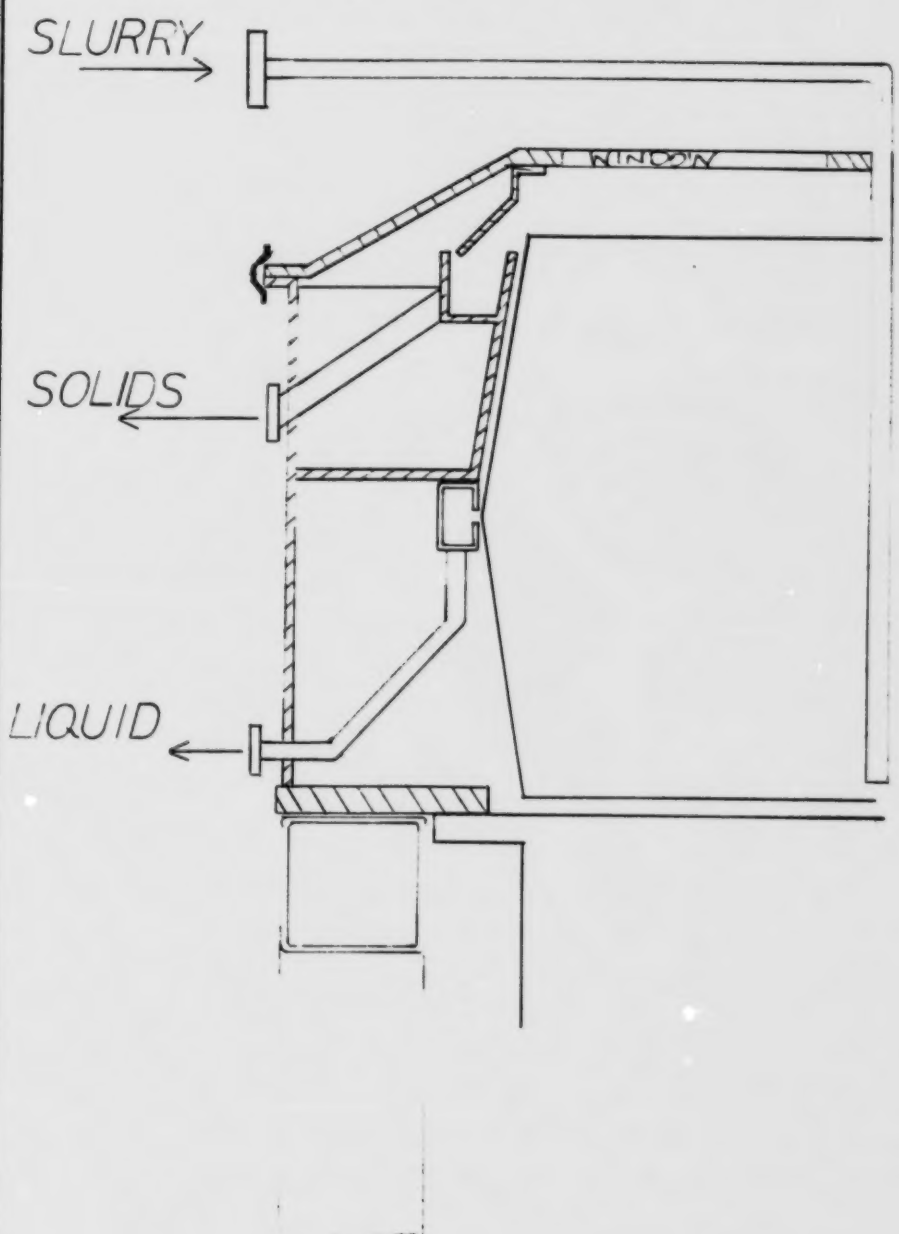
Minutes of Meeting (Cont'd)
Project
Date: June 1st, 1984

DISCUSSIONS	ACTION
taper at the inside face. SBRG will calculate recess depth requirements.	SBRG
The vent holes in the piston face will be enlarged to approximately 1/2" diameter and moved radially outward. This will permit the drainage of liquid left in the separator bowl when the system is brought to rest which can then exit the bowl through the existing slots at the lower edge.	DSMA
The vent holes will be drilled at an angle to deter liquid from passing through the piston when the centrifuge is in operation.	DSMA
A tapered face at the lower end of the separator bowl will encourage liquid to leave the bowl and a depressed trough with a valved port in the mounting flange will permit periodic drainage of this liquid.	DSMA
4. ELECTRICAL CONTROLS	
It was agreed that a meeting will be arranged between C. Balkwill of DSMA and an SBRG electrical representative to review electrical/controls requirements for the Centrax System installation in order to determine and minimize the level of DSMA design effort required.	SBRG/DSMA
Next design review meeting will be held on 5 June at 1:30 p.m.	

DSMA International Inc. Toronto, Canada	Design Report	
	Project No. 4053	D.R. No.
	By T.D. Date 5/6/3	Page
Subject SCRAPER PISTON PROPOSED MODS	Checked Date	Of



DSMA International Inc. Toronto, Canada	Design Report	
	Project No.	D.R. No.
	By Date	Page
Subject: SINGLE STAGE CONTAINMENT VESSEL	Checked Date	Of



NOTES ON A MEETING WITH SKF CANADA

PROJECT: SBRG Centrifugal Separating Machine
Project No. 4053

PLACE: DSMA International Inc.
10 Park Lawn Rd.
Toronto, Ontario
M8Y 3H8

DATE: 4th June, 1984.

PRESENT:

J. J. Sickinger - SKF Engineering
R. W. A. Rice - SKF Sales
P. Duggan - DSMA

DISTRIBUTION:

S. L. Hodd - SBRG
P. Groeneweg - SBRG
P. Duggan - DSMA
File 4053/B1

The meeting was held to discuss the bearings to be used for the separator sub-assembly drive unit.

During the conceptual design phase, SKF precision spindle bearings were selected for the support of the high speed bowl/scraper piston assembly and SKF tapered roller bearings were chosen for the application of the scraper axial load by the hydraulic actuator.

SKF agreed that the bearing arrangement will operate successfully as shown, but expressed concern about the lubrication aspects and ultimate bearing life.

DSMA expressed a desire to operate the bearings with grease lubrication rather than continuous oil lubrication, in order to minimize mechanical complications.

SKF feels that the vertical orientation of the equipment will tend to allow grease to pass through the lower bearings and it may prove difficult to maintain adequate lubrication at the upper, deep groove bearing. This could be improved by injecting grease above this bearing, behind the labyrinth seal.

The upper deep groove bearing should be allowed to slide at its outer diameter in order to compensate for thermal effects inside the containment vessel. This bearing will experience radial loading only.

NOTES ON A MEETING WITH SKF CANADA (Cont'd.)

DATE: 4th June, 1984.

The duplex pair of lower bearings must support radial loads and react the axial thrust loads required to push the solid cake up the bowl surface. This is estimated at 80,000 N. Additional radial loads are applied by the drive belt/pulley arrangement.

SKF agreed to consider the design further and perform a load/life analysis on the bearing sets based on a rotational speed of 4600 rpm. DSMA agreed to compile a profile of the manner in which the bearings experience the axial scraper loads.

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: DSMA International Inc.
10 Park Lawn Road
Toronto, Ontario
M8Y 3H8

DATE: 5 June 1984

PRESENT: P. Groeneweg - SBRG
P. Duggan - DSMA

Distribution: S.L. Hodd - SBRG
P. Groeneweg - SBRG
C. Balkwill - DSMA
P. Duggan - DSMA
File 4053/B1

DISCUSSIONS	ACTION
1. CONTAINMENT VESSEL A revised sketch of the proposed containment vessel was reviewed and the following changes agreed: The inner wall of the solids collection bowl will be eliminated and stiffening gussets added to the underside of the bowl. The solids transfer conduit will be enlarged and sloped to the outside wall at 15°. A circular plate mounted on the outside surface of the rotating separator bowl may be required in the future to deflect dropped solids but provision for this will not be made at this time. The solids deflector cone will be sloped at a shallower angle with a minimum 1" gap above the separator bowl.	

DISCUSSIONS	ACTION
The outside deflector cone will be attached to the underside of the top cone using the same fixing screws as the inner cone. Only one cone is required in operation at any time.	
The outside deflector cone will have its lower edge submerged in the solvent and a "quiet zone" outside this diameter will be preserved for the liquid overflow point.	
The mixer will be mounted at the end of a conduit projecting from the outside wall of the containment vessel in order to keep seals clear of the solvent with the impeller submerged in the liquid. SBRG will specify the mixer requirements.	SBRG
The inlet pipe for solvents will also project through the side wall between the outside wall and the deflector cone and the eductor connected with the top lid removed.	
2. SCRAPER PISTON	
A revised sketch of the scraper piston profile was reviewed and the following changes agreed:	
The inside angle of the piston recess will be reduced to 5°.	
The recess width will be maintained at 10 mm.	
The recess depth requirements will be calculated by SBRG.	SBRG
A negative step will be created at the upper separator bowl interface to assist the movement of cake and liquid.	
The lower bowl drain slot angle will be reduced to 5°.	
3. DRIVE ASSEMBLY BEARINGS	
Discussions are continuing with SKF and it was agreed that bearings prepacked with grease will be considered in an effort to eliminate periodic injection of grease.	DSMA
A load/time profile was agreed for the scraper piston motion and this profile will be used by SKF to perform a bearing load/life analysis based upon a life of 5000 hr operation.	DSMA
Next meeting to be held 7 May at 1:30 p.m.	

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: Sandwell Beak Research Group
6870 Goreway Drive
Mississauga, Ontario
L4V 1L9

DATE: June 6, 1984

PRESENT: P. Groeneweg - SBRG
L. Howarth - SBRG
C. Balkwill - DSMA

Distribution: S.L. Hodd - SBRG
P. Groeneweg - SBRG
C. Balkwill - DSMA
P. Duggan - DSMA
L. Howarth - SBRG
File 4053/B1

DISCUSSIONS	ACTION
1. GENERAL The purpose of this meeting was to review the division of responsibilities with regard to the electrical and control content, and related equipment, between DSMA and SBRG, and to define the extent of input in the DSMA content. 2. DSMA/SBRG CONTENT DIVISION DSMA to limit their input to the definition of the main centrifuge drive including a bid spec., the design of the scraper control system and the definition of the required hydraulic control system. SBRG will handle all remaining equipment requirements (e.g. slurry pump, solvent mixer and several other systems not known to DSMA), and will handle all installation details. This includes the supply of power circuits as required, definition of required field cabling, etc.	

DISCUSSIONS	ACTION

DSMA to prepare bid specifications for the separator drive and hydraulic power pack and a control schematic for the scraper control system. In the case of the separator drive and the hydraulic power pack, SBRG will hook up this equipment from the suppliers', documentation. In the case of the scraper control, SBRG will manufacture the required control system, incorporating it in a larger control panel used for other systems. A PLC may be considered instead of hardware relays, but either way SBRG will work off of a conventional relay logic schematic. No additional connection diagrams are required.

The possibility of incorporating the scraper control system in the hydraulic power pack control system was discussed. While this is probably feasible it was felt that this would result in an additional engineering and manufacturing cost component by the hydraulic power pack supplier, and SBRG can easily handle this.

3. SEPARATOR DRIVE

While a DC variable speed drive seems to be the preferred type at the present time a better cost comparison should be made between DC and a variable frequency AC drive when final speed/torque relationships are established. SBRG must still establish the drive torque component associated with the slurry load, and the variation of drive torque with the feed rate of the slurry. The drive size should not be the limiting factor on feed rate.

While accuracy of drive speed is not an important factor, it is important to have an actual indication of speed using a tachometer, opposed to an implied speed indication by measurement of drive power. Whether speed feedback is actually used in the drive controller or not, is to be decided after costing of same is established.

Another consideration in drive selection is the preference for a totally enclosed drive motor. While this is readily available in an AC squirrel cage motor, the cost of a totally enclosed DC motor must still be reviewed. The drive control cabinet must also be totally enclosed and gasketted. In harsh atmospheres SBRG's normal practice is to pressurize such enclosures with nitrogen to ensure no ingress of external air.

DISCUSSIONS	ACTION

The internal heat rejection must be reviewed for this cabinet and if an air exchange is required for heat removal, the SBRG nitrogen system can be configured to permit a small, steady purge.

The drive should be provided for operation on a 575 VAC, 3 phase supply.

4. SCRAPER CONTROL

Considerable discussion was held regarding operator controls and indications for the oscillatory scraper actuator including manual over-ride and position indication requirements if a jam occurs. It was concluded (by SBRG) that it was best to set the hydraulic system pressure below a level that could cause any structural damage and not provide any hydraulic over-ride capabilities. If the scraper jammed, the operator should disable the hydraulics and use some mechanical means to manually force a scraper stroke while observing local areas of concern. Manual handvalves are sufficient to permit free hydraulic oil displacement during manual stroking of the scraper. A pressure guage should be incorporated in each of the two feed/return lines to the hydraulic cylinder to permit the monitoring of the actuator loads.

Provision shall be made in the control system to stop the scraper at either end of travel. A 2-position directional control valve was considered appropriate, as a centre position with closed ports could not be relied on to hold the scraper under load at an intermediate position. The use of pilot-operated check valves for this purpose was considered more sophisticated than warranted.

As the actual position of the scraper is of interest under a jammed condition, a continuous analog position indicator is necessary. This will require driving a linear displacement transducer from the mechanical linkage. While linear potentiometers were considered to be adequate from a life point-of-view, the price of non-contact transducers such as LVDT's and capacitance types should at least be reviewed and cost comparisons made.

DISCUSSIONS	ACTION

The possibility of monitoring the continuous position signal by the control logic and using it to trigger direction reversal was discussed. This uses conventional hardware (analog alarm relays) which are readily available and quite reliable. However, preference was given to the use of a single toggle-type limit switch for triggering the stroke reversal. It was felt that this would be cheaper and the simplicity was preferred.

Both the stroke length and the stroke frequency must be adjustable, but simple manual presets are adequate. This could consist of readjusting the striker plates for the limit switch for stroke length and changing a throttle valve on the hydraulic flow circuit for stroke speed.

A double-ended cylinder was discussed as a simple means of providing a linkage to drive the linear position transducer and installing adjustable striker plates for actuation of the toggle limit switch. However, this detail must come out of the mechanical design considerations.

5. HYDRAULIC SYSTEM

SBRG has concerns of pressure shocks on direction reversals of the scraper drive mechanism. Some end of travel deceleration scheme should be considered.

The hydraulic power unit should be sized for an addditonal three centrifuge units in the future. Appropriate piping take-offs should be provided but no other hardware is to be included in the initial package.

The hydraulic power pack should be a self-contained unit with all controls, interlocks, etc. prewired. While SBRG has no supplier preference an appropriate cost/quality trade-off should be made.

It was not discussed whether the pump starter should be part of the power pack or whether SBRG already has an appropriate starter.

6. ENGINEERING COSTS

In view of a better definition now of what DSMA should confine their input to, their engineering estimates will be updated accordingly.

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: DSMA International Inc.
10 Park Lawn Road
Toronto, Ontario
M8Y 3H8

DATE: 8 June 1984

PRESENT: P. Groeneweg - SBRG
P. Duggan - DSMA

Distribution: S.L. Hodd - SBRG
P. Groeneweg - SBRG
C. Balkwill - DSMA
P. Duggan - DSMA
File 4053/B1

DISCUSSIONS	ACTION
1. CONTAINMENT VESSEL The latest sketch of the containment vessel was reviewed and the following changes agreed: The base of the solids collection bowl will be raised and the entrance to the transfer conduit will cover both base and sidewall area to ensure that solids do not remain in the bowl. The solvent inlet pipe will be moved upstream of the mixer assembly and the overflow pipe will be upstream of the inlet. The mixer turbine will be located immediately upstream of the transfer conduits and projecting at an angle which will ensure that solvent cannot reach the mixer seals.	

DISCUSSIONS	ACTION
2. SCRAPER PISTON	
SBRG are concerned that the present design of the scraper piston will not be capable of handling the freshly deposited wet cake and several design changes are proposed.	
SBRG suggest that the piston rings are eliminated and the profile of the piston reduced with a thin flexible scraper ring attached to prevent solids migrating behind the piston.	
Six projecting spikes are also proposed which will lead the piston and form grooves through the wet cake for the drainage of centrifuged liquid.	
DSMA expressed doubts that this design modification would allow the piston circumference to be used as a support and guide for the scraper piston assembly.	
It was agreed that the drive assembly arrangement would be reviewed with the aim of installing support bushes for the piston shaft and allowing clearance between the piston and the separator bowl.	DSMA
The solids take-off ports at the base of the separator bowl will be eliminated and replaced with a mitred corner to include small breather holes.	DSMA
The recess in the piston head used to form the wet cake into shape will be 10 mm wide and 3 mm deep.	DSMA
The piston stroke rate will be maintained at a level greater than the slurry feed rate.	
A stroke frequency between 3 sec. and 2 mins is required to be adjusted by regulation of the hydraulic flow. It should also be feasible to delay the motion of the piston at the bottom of its stroke.	
Next meeting to be held on 12 June at 1:30 p.m.	

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: DSMA International Inc.
10 Park Lawn Road
Toronto, Ontario
M8Y 3H8

DATE: 12 June 1984

PRESENT: P. Groeneweg - SBRG
P. Duggan - DSMA

DISTRIBUTION: S.L. Hodd - SBRG
P. Groeneweg - SBRG
C. Balkwill - DSMA
P. Duggan - DSMA
File 4053/B1

DISCUSSIONS	ACTION
1. SCRAPER PISTON DSMA presented a sketch of the scraper spike scheme suggested by SBRG at the last project meeting. This sketch shows that with the present bowl design, in order to form a complete channel for liquid transfer, a spike length of 70 mm would be required. In addition to the low rigidity that this length represents, the spikes would interfere with the liquid take-off ports. It was agreed that the spike length will be reduced to 35 mm from the piston face and SBRG will review the bowl dimensions in an attempt to reduce the overall length and minimise the piston axial loading. In order to prevent the migration of solid particles behind the piston, SBRG have proposed that the piston rings are removed and replaced by a thin flexible scraper ring to be located at the base of the piston. At the bottom of the piston stroke, this scraper	SBRG

DISCUSSIONS	ACTION
must be able collect particles which have been deposited at the outer edge of a tapered face at the bottom of the bowl. DSMA pointed out that this approach would lead to a highly stressed, thin section piston, which may not be able to handle the axial loads between the scraper ring and the spike assembly. DSMA to consider this design in more detail.	DSMA
SBRG agreed to consider experiments which may be performed to determine both the compressibility of the solids cake and the coefficient of friction between the cake and the bowl wall.	SBRG
This may permit a relaxation in the design criteria for the piston and drive assembly. The scroller type centrifuge with the scroll operational over a 30 mm bowl length was briefly reviewed but it was agreed that the scraper piston approach has more potential at this stage.	
2. DRIVE ASSEMBLY BEARINGS SKF have confirmed that the highly loaded tapered roller bearings which transfer load from the hydraulic actuator will have a short life and propose the use of a duplex pair of angular contact bearings operating in tandem which would be located outside the existing bearing set. Since both sets of duplex bearings experience similar axial loads it may be feasible to use identical bearings for both applications. The upper, deep groove bearing would be replaced by an angular contact bearing to counteract the lower tandem set and SKF feel that temperature differentials would present no problems with this arrangement.	
3. AXIAL SPLINE Hamilton Gear have reviewed the spline requirements and expressed concern regarding the radial play in the spline (0.003" - 0.005") which may cause instability in the rotating components. They suggest the use of well fitted bushes with a captive key arrangement to carry rotational loads. DSMA to investigate and produce a revised sketch of the drive assembly.	DSMA
Next meeting to be held at 1:30 p.m. on 14 June.	

DSMA International Inc.

Toronto, Canada

Design Report

Project No. 4053	D.R. No.
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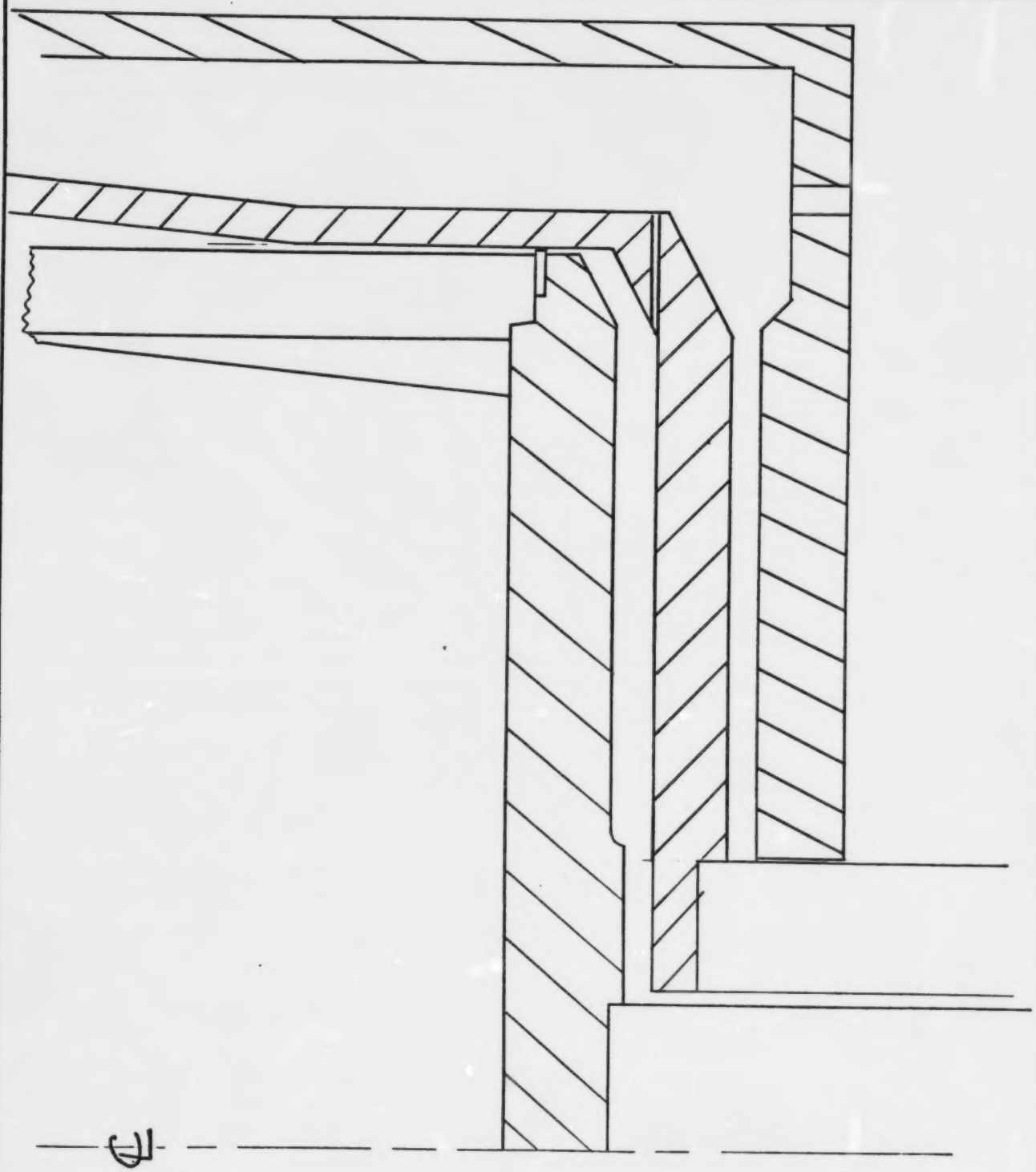
Subject: MODIFIED SCRAPER PISTON DESIGN



DSMA International Inc.

Toronto, Canada

Design Report

Project No. 4053	D.R. No.
By PD. Date 12/6/84	Page
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Subject
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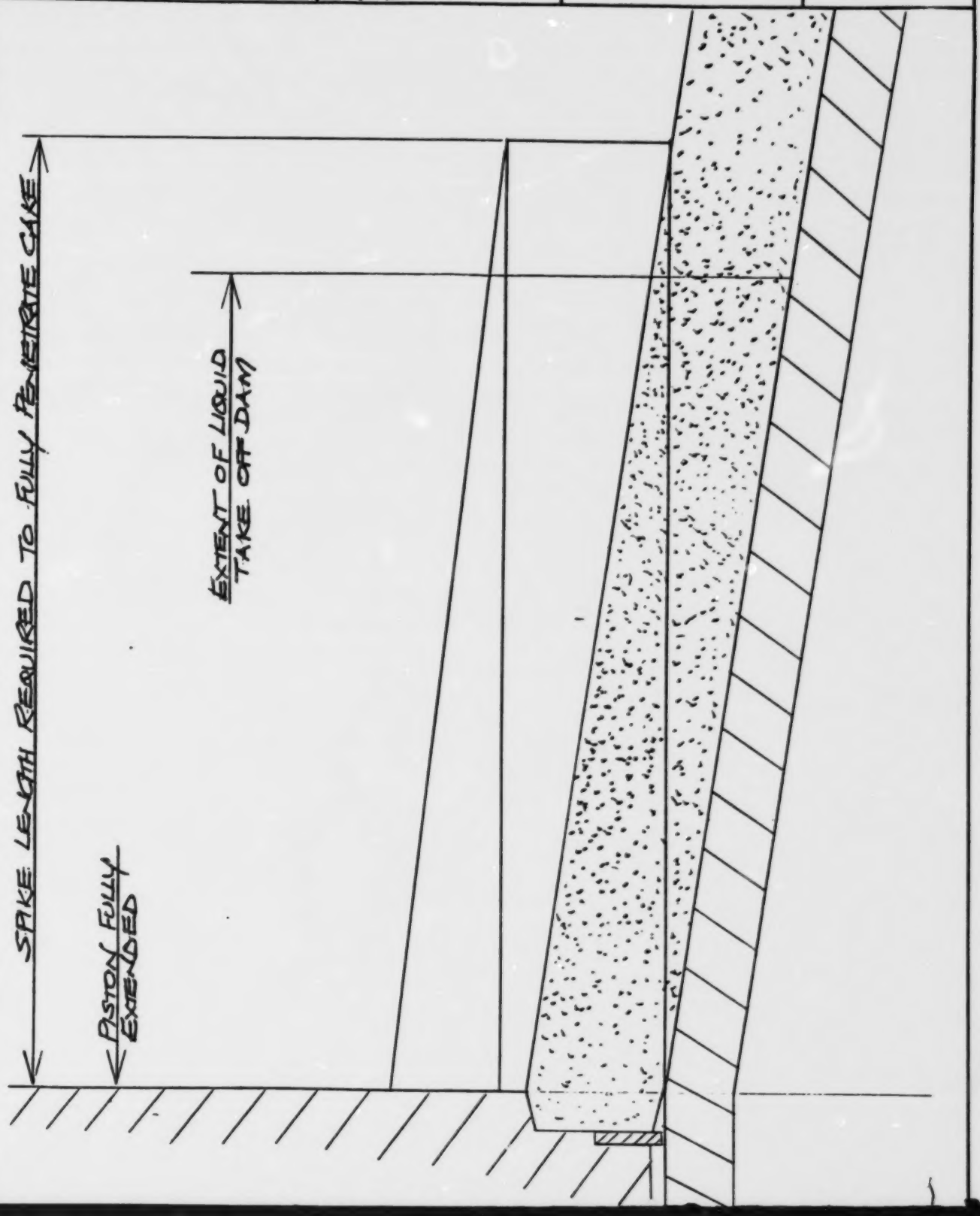

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: DSMA International Inc.
10 Park Lawn Road
Toronto, Ontario
M8Y 3H8

DATE: 14 June 1984

PRESENT: P. Groeneweg - SBRG
P. Duggan - DSMA
R. Steger - RPSP (part-time)

DISTRIBUTION: S.L. Hodd - SBRG
P. Groeneweg - SBRG
C. Balkwill - DSMA
P. Duggan - DSMA
File 4053/B1

DISCUSSIONS	ACTION
1. PISTON SEALS Rudy Steger of Reena Packing and Seal Products attended the meeting to present a seal arrangement which has the potential of meeting requirements for the scraper piston. The seal arrangement known as a hydrolock assembly is manufactured from glass reinforced nylon 1903 and consists of a guide ring, a series of V rings and a back-up wear ring. The only other seal possibilities are: Cast Iron Rings: OK with solvents but will leak and trapped solid particles will score the cylinder bore. Fabric or Teflon Seals: Tend to dissolve in solvents and will be rapidly destroyed by solid particles. Vinolic Seals: May be OK with solvents but epoxy laminated material will swell in contact with oil.	

DISCUSSIONS	ACTION
SBRG expressed concern about the ability of the 1903 material to withstand the solvent effects of the process Anthracine oil at temperatures up to 200°C. Mr. Steger agreed to discuss the working conditions with Dupont, the manufacturers of the 1903 material and provide an answer to DSMA by 15 June.	RPSP
2. SEPARATOR BOWL Since the last meeting, SBRG have performed experiments on the centrifuged cake obtained at various stages of the separation process. They have discovered that cake separated at an early stage in the process is a non-flowable liquid with a putty like consistency at the process temperature. At room temperature, this material has high compressive and tensile strength. Cake separated at a later stage in the process is a brittle material with high compressive strength but low tensile strength. SBRG have concluded from these experiments that in both the early and late stages of the process the present separator design will not be capable of pushing the cake up the bowl in the desired manner. SBRG propose that the bowl assembly be redesigned to eliminate the tapered sections. The bowl will remain at 250 mm diameter but the overall working length will be reduced to 150 mm and the scraper piston will travel the full length of the bore. The liquid take-off ports will be relocated at the upper end of the separater bowl and only 2 ports will be required at 180° intervals. DSMA will examine the new design requirements and review the options for driving the scraper piston over its extended stroke.	DSMA
If required, the piston shaft may be supported at both upper and lower ends. The slurry feed pipe may be offset radially if required. DSMA agreed to examine the possibility of using a rotating hydraulic cylinder to operate the scraper piston by supplying oil through a slip ring assembly.	DSMA

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: DSMA International Inc.
10 Park Lawn Road
Toronto, Ontario
M8Y 3H8

DATE: 18 June 1984

PRESENT: P. Groeneweg - SBRG
P. Duggan - DSMA

DISTRIBUTION: S.L. Hodd - SBRG
P. Groeneweg - SBRG
C. Balkwill - DSMA
File 4053/B1

DISCUSSIONS	ACTION
1. PISTON SEALS R. Steger of Reena Packing and Seal Products is investigating the use of 1903 glass reinforced nylon seals with Anthracine oil and a response is anticipated shortly. A sample of this material was supplied to SBRG who will immerse it in Anthracine oil to determine short and long range effects.	SBRG
2. LIQUID EXIT PORTS It was agreed that liquid take-off ports will be redesigned to ensure that trapped solids will be removed by the centrifuge action without hindering the flow of liquid. The tapered section above the liquid ports will be designed with six facets to assist the break-up of cake during removal.	DSMA

DISCUSSIONS	ACTION
3. PISTON ROD It was agreed that the length of piston rod required with the present design to achieve a piston stroke of 150 mm is excessive and a redesign in this area is required. DSMA agreed to investigate the use of hydraulic telescoping cylinders combined with a hydraulic rotating joint in order to produce a more compact mechanical arrangement.	DSMA
4. POTENTIAL FABRICATORS A list of potential fabricators for the centrifugal separator equipment was supplied by SBRG. DSMA agreed to compile a similar list.	DSMA
Next meeting to be held on 20 June at 1:30 p.m.	

RECOMMENDED FABRICATORS BY SBRG June 18, 84

Machine Shops

Edgar Sharpe & Associates	743-8144	light work, very good
John MacNab		
Rexdale Tool	241-4035	heavier work
Manfred Luther		
Ben Machine	678-1555	medium work
Peter or Matt		
Northwest Precision	742-8082	larger or heavy work
Sam or Pat		

Sheet Metal

Acra-Fab	675-1126
Jack Bownean	
AG Baird	749-2432
Ted Forbes/Bill Watt	

Grinding

Vic's Grinding	741-3631
Hendrik's Precision	749-0982

Welding

Specialist Weld	823-4080
Bill Douglas	

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: DSMA International Inc.
10 Park Lawn Road
Toronto, Ontario
M8Y 3H8

DATE: 20 June 1984

PRESENT: P. Groeneweg - SBRG
P. Duggan - DSMA

DISTRIBUTION: S.L. Hodd - SBRG
P. Groeneweg - SBRG
C. Balkwill - DSMA
File 4053/B1

DISCUSSIONS	ACTION
1. SEPARATOR SUB ASSEMBLY Two revised options for driving the scraper piston in the axial direction were reviewed. The first option incorporates a rotating hydraulic cylinder at the centre of the bowl drive shaft and the second option includes a custom designed hydraulic actuator using the bowl drive shaft as the cylinder bore. Both these schemes require that the hydraulic oil is carried across an axially mounted, dual channel, rotary joint capable of 4600 RPM rotational speed at the operational hydraulic system pressure. Rotary joints are available from Aeroquip and Deublin but neither of these are capable of meeting the pressure and speed requirements simultaneously. Since bearings and seals are available to meet these requirements it may be feasible to design a suitable rotary joint. DSMA agreed to investigate this further.	DSMA

DISCUSSIONS	ACTION
The integration of a standard hydraulic cylinder creates problems with inlet and outlet port connections and it was agreed that DSMA will pursue the possibility of custom designing a cylinder within the separator bowl drive shaft.	DSMA
One significant advantage of these options is that the axial scraper loading is reacted within the bowl drive shaft and consequently the bowl support bearings do not experience the scraper loads. This will result in much increased life for these bearing assemblies.	
DSMA also agreed to examine the possibility of lubricating the support bearings with the hydraulic oil supply.	DSMA
One problem that the integrated hydraulic cylinder produces is the incorporation of limit or proximity switches to indicate the extremes of piston travel. DSMA agreed to investigate possible solutions.	
The scraper piston will be entirely supported by the hydraulic cylinder bushes and there will be no physical contact between the piston and bowl wall.	
2. LIQUID TAKE-OFF PORTS	
It was agreed that the liquid take-off ports will be redesigned to ensure that solid cake slides over the ports without clogging the exit duct.	
Both SBRG and DSMA will consider the design of these ports further to ensure a foolproof design.	SBRG/DSMA
Next meeting will be held on 22 June at 1:30 p.m.	

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: DSMA International Inc.
10 Park Lawn Road
Toronto, Ontario
M8Y 3H8

DATE: 22 June 1984

PRESENT: P. Groeneweg - SBRG
P. Duggan - DSMA

DISTRIBUTION: S.L. Hodd - SBRG
P. Groeneweg - SBRG
C. Balkwill - DSMA
File: 4053/B1

DISCUSSIONS	ACTION
1. LIQUID TAKE-OFF PORTS SBRG suggested a modification to the liquid take-off port design. A more gentle sloping section is proposed at the top edge of the bowl to allow the solid cake to slide more easily over the edge. The liquid take-off ports would be located within this section with side wall boundaries to prevent cake clogging the exit port. The upstream boundary wall would be cut away at its upper edge to permit centrifuged liquids to flow into the exit port. This sub assembly would then act as a "plough separator" for the deposited cake as it is pushed up the separator bowl by the scraper piston. DSMA agreed to produce a drawing layout of this proposed revision.	DSMA
2. SCRAPER PISTON SBRG proposed some detail design changes to the scraper piston profile and separator bowl contour. A tungsten carbide coated blade will be bolted to the scraper piston for solids removal. The supporting piston thickness will be minimized to limit migration of solid particles behind the piston. The lower face of the bowl will be sloped at 45° with a drainage port provided to remove any liquid present. The piston head inboard of the scraper	

DISCUSSIONS	ACTION
blade will be sloped to prevent interference with the upper solids removal contour. A flat section will minimize solids hang-up at the liquid exit port and a sloping section to the piston centre will provide "agglomeration" of the centrifuged slurry particles. This face will be sloped at 30° and the slurry feed pipe will protrude 20 mm into the separator bowl.	
3. SCRAPER PISTON DRIVE The proposed hydraulic drive system for the scraper piston was reviewed. In order to reduce the system operating pressure to 2000 psi, a piston diameter of 3 in. is suggested. With a rod diameter of 2½ in. this should provide adequate piston support over the 150 mm stroke length.	
It was agreed that the hydraulic cylinder piston should make mechanical contact before the scraper piston interferes with bowl components at the stroke extremes. DSMA will investigate the possibility of incorporating hydraulic snubbers in the cylinder end caps to decelerate the scraper piston.	DSMA
The hydraulic rotary joint will be designed as a separate sub-assembly for an operational pressure of 2000 psi and a rotational speed of 4600 RPM.	
4. PISTON POSITION DETECTION Techniques for detecting scraper piston position were reviewed and it was agreed that limit switches or proximity sensors will be difficult to incorporate within the rotating hydraulic cylinder assembly.	
An ultrasonic sensing system manufactured by Tecknor of St.Louis may be capable of sensing the scraper piston position if installed in the containment vessel cover. DSMA agreed to investigate this possibility.	DSMA
5. PROJECT SCHEDULE DSMA agreed to produce a new layout drawing for the separator assembly incorporating the rotating hydraulic cylinder by 29 June.	DSMA
Detail design of this assembly is scheduled to commence by 3 July and ordering of parts by 9 July in order to meet the original schedule requirements.	
:am	

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: DSMA International Inc.
10 Park Lawn Road
Toronto, Ontario
M8Y 3H8

DATE: 26 June 1984

PRESENT: P. Groeneweg - SBRG
P. Duggan - DSMA

Distribution: S.L. Hodd - SBRG
P. Groeneweg - SBRG
C. Balkwill - DSMA
P. Duggan - DSMA
File: 4053/B1

DISCUSSIONS	ACTION
1. LIQUID TAKE-OFF PORTS DSMA presented a layout of the modified liquid take-off design. Further design features were suggested by SBRG including a plough profile at the leading edge and a protective canopy above the exit port. It was agreed that the profiled wall height should be raised to ensure efficient removal of cake on either side of the exit port. The present port is sized at 3 mm dia. and SBRG agreed to review this size requirement prior to final detail design. DSMA will revise the exit port layout drawing to accommodate these features.	SBRG DSMA
2. SCRAPER PISTON SBRG suggested some contour changes to the scraper piston profile. The central horizontal section will be increased in diameter to ensure full acceleration of the centrifuged particles. The edge profile will be changed to conform to the shape of the liquid take-off port and the hardened scraper ring will be modified to a sharp corner at the outer edge.	

DISCUSSIONS	ACTION
3. HYDRAULIC CYLINDER DSMA suggested that the hydraulic cylinder design might be based on a standard Parker cylinder with 3¼" bore. This would allow the use of standard Parker products including the piston, piston rod, rod gland and associated seals. Parker have agreed to supply a marked up sketch of this cylinder size showing component dimensions and tolerance requirements. DSMA suggested that the incorporation of hydraulic cushions would not be practical since the scraper piston is required to operate over the full stroke between the separator bowl and the liquid take-off ports. This results in no stroke allowance for cushioning within the cylinder. Cushioning may be feasible outside the cylinder using cross over relief valves.	
4. ROTARY JOINT With the use of a rotating hydraulic cylinder a rotary joint is required to carry hydraulic oil to and from the cylinder. Standard rotary joint designs by Deublin and Aeroquip have been reviewed but at present no joints seem available capable of 4600 RPM rotation at 2000 psi pressure. It may be feasible to custom design a dual passage joint with a controlled leakage to meet the separator requirements. DSMA agreed to investigate further.	DSMA
5. SCRAPER CONTROL DSMA presented three potential schemes for control of the scraper piston motion with relative estimated hardware costs. These included a "bang-bang" system incorporating a directional control valve, a proportional control valve system and a servovalve controller. SBRG agreed to review these schemes in order to determine the level of sophistication required for the control system.	SBRG
6. PROJECT SCHEDULE DSMA agreed to proceed with a drawing showing the final concept for the centrifugal separator. This will be incorporated in a report which describes the present design and re-evaluates hardware costs and engineering costs to complete the mechanical and controls design.	

:am

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: DSMA International Inc.
10 Park Lawn Road
Toronto, Ontario
M8Y 3H8

DATE: 29 June 1984

PRESENT: P. Groeneweg - SBRG
P. Duggan - DSMA

DISTRIBUTION: S.L. Hodd - SBRG
P. Groeneweg - SBRG
C. Balkwill - DSMA
P. Duggan - DSMA
File 4053/B1

DISCUSSIONS	ACTION
1. SCRAPER PISTON A revised layout of the centrifugal separator was reviewed and several design modifications agreed. The piston fastening nut will be replaced by a bolted flange arrangement to prevent obstruction of the incoming slurry. The liquid drain hole in the piston head will be relocated in the horizontal portion of the piston face. An additional set of drain holes will be provided in the lower face of the separator bowl in order to remove liquids following shut down of the equipment. 2. ROTARY JOINT Further discussions with Deublin indicate that the design of a hydraulic rotary joint which can rotate at 4000 RPM and operate at 2000 psi is feasible using either special low wear characteristic face seals or controlled leakage labyrinth seals. DSMA agreed to	

DISCUSSIONS	ACTION
review the possibility of connecting two standard single stage units in series.	DSMA
3. PISTON STROKE CYCLES SBRG estimate the following scraper piston cycle profile will be required as a worse case. Top to bottom of bowl = 4 sec Bottom to top of bowl = 31 sec Dwell at top of bowl = 0 sec Dwell at bottom of bowl = 52 sec The slurry input feed will be suspended whilst the piston is in motion.	
4. SYSTEM PRESSURE It was agreed that a reduction in system hydraulic pressure to 1500 psi will be considered if 2000 psi is not considered feasible for the rotary joint or cylinder design, since the axial load capability will still meet cake removal requirements based upon a 0.5 coefficient of friction.	
5. HYDRAULIC SYSTEM CONTROL It was agreed that the use of a servovalve would probably be most practical for piston motion control. A directional control valve would require additional pilot operated check valves in order to hold the piston in any desired position. A variable flow control valve would be required to adjust the piston speed. Hardware required for this system would not prove economical when compared with the use of a hydraulic servovalve since the servovalve can be used for speed and position control. Oil filtration requirements are, however, more critical for the servovalve application.	
6. PROJECT SCHEDULE DSMA agreed to proceed with the final concept drawing for the centrifugal separator to be incorporated in a design report next week. Detail design of the separator will proceed in parallel.	

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: DSMA International Inc.
10 Park Lawn Road
Toronto, Ontario
M8Y 3H8

DATE: July 4, 1984

PRESENT: P. Groeneweg - SBRG
P. Duggan - DSMA

DISTRIBUTION: S.L. Hodd - SBRG
P. Groeneweg - SBRG
C. Balkwill - DSMA
P. Duggan - DSMA
File 4053/B1

DISCUSSIONS	ACTION
1. LIQUID TAKE OFF PORTS DSMA presented a revised version of the separator bowl liquid take off ports incorporating a plough separator contour at the leading edge. SBRG agreed to review this design.	SBRG
2. PISTON ROD SEAL SBRG have conducted tests on the seal material sample supplied by Reena Packing by submerging the seal assembly in the process solvent at high temperature. The blue seal material became soft and deformed although the black seal material did not seem to absorb solvent. SBRG suspect that the black material loses its strength and agreed to conduct further tests at 200°C without contact with solvent.	SBRG
DSMA to contact Reena Packing and determine effects of high operational temperatures on both seal materials.	DSMA

DISCUSSIONS	ACTION
Since this seal is in direct contact with the separator bowl environment it is essential that its operation is confirmed prior to final design of the equipment.	
3. SUPPORT BEARINGS The angular contact support bearings must also be given careful consideration since these too are located close to the high temperature environment of the separator bowl.	
DSMA will review methods of cooling the upper portion of the rotating assembly in order to maintain reasonable operating temperatures for both seals and bearings.	DSMA
Next meeting to be held 6 July at 1:30 p.m.	

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: DSMA International Inc.
10 Park Lawn Road
Toronto, Ontario
M8Y 3H8

DATE: July 6, 1984

PRESENT: P. Groeneweg - SBRG
P. Duggan - DSMA
V. Silaghi - DSMA

DISTRIBUTION: S.L. Hodd - SBRG
P. Groeneweg - SBRG
C. Balkwill - DSMA
V. Silaghi - DSMA
P. Duggan - DSMA
File 4053/B1

DISCUSSIONS	ACTION
1. SCRAPER PISTON Detail design of the scraper piston has commenced and it was agreed that piston stresses will be based upon a maximum pressure of 2000 psi acting upon the hydraulic cylinder piston. If increased scraper piston thickness is required to handle this load, the vent hole in the piston face will be angled in two directions in order to preserve the aperture in the horizontal upper face.	DSMA
2. HYDRAULIC CYLINDER DSMA suggested that the piston diameter is increased within the existing bearing bore size in order to maximise the axial piston load capability for a given system pressure. This can be achieved by reducing the cylinder wall thickness and relocating the bearing assemblies.	

DISCUSSIONS	ACTION
3. BEARINGS DSMA are investigating the use of a Kaydon single four point contact bearing to replace the SKF duplex pair of angular contact bearings. This would simplify the bearing arrangement and reduce the overall bearing size required to meet the rotational speed requirement. Since axial loads are now reacted internally within the hydraulic cylinder arrangement the support bearings are lightly loaded and a significant increase in bearing life will result.	DSMA
4. PISTON ROD SEAL SBRG have conducted further tests on the piston rod seal sample supplied by Reena Packing and have concluded that high process temperatures alone have little effect upon the seals. The combination of high temperature and solvent contact does however have a detrimental effect upon the seals.	
5. THERMAL EFFECTS SBRG expressed concern about mechanical drive and seal components in close proximity to the high temperature (180°C) separator bowl. It was agreed that these effects will be minimised by lowering the mechanical drive assembly and inserting a 2" section of thermal insulation at all interfaces with the separator bowl and containment vessel. DSMA agreed to review potential insulation materials for this application.	DSMA
6. HYDRAULIC ROTARY JOINT DSMA suggested that since the required scraper piston loads are unknown it would be appropriate to install a standard "Deublin" hydraulic rotary joint to supply oil to the rotating hydraulic cylinder. SBRG have conducted further tests on the centrifuged cake material and have concluded that the coefficient of friction between cake and bowl may be greater than the 0.5 factor assumed in earlier calculations. However, with the use of a shorter bowl and an increased hydraulic piston size it may be feasible to reduce the hydraulic system pressure to a level which is acceptable for continuous use of a standard rotary joint. This would provide a low cost, low risk approach for the pilot operation and a custom designed joint could be incorporated at a later date if this proved necessary.	

DISCUSSIONS	ACTION
DSMA agreed to review these loads in more detail in order to determine the feasibility of using a standard rotary joint product.	DSMA
7. INTERIM REPORT DSMA agreed to proceed with the completion of an interim report to review the revised mechanical design and re-estimate the engineering and hardware costs. Detail design of the mechanical hardware will continue without interruption.	DSMA
Next meeting to be held 16 July at 1:30 p.m.	

APPENDIX B

POTENTIAL FABRICATORS

POTENTIAL FABRICATORS

Machine Shops

1. Edgar Sharpe & Associates — Tel: 743 8144
   1983 Kipling Avenue
   Rexdale, Ontario
   M9W 4G4

   Contact: John McNab

2. Rexdale Tooling — Tel: 241-4035
   70 Belfield Rd.
   Unit 4
   Rexdale, Ontario

   Contact: Manfred Luther

3. Northwest Precision — Tel: 742-8082
   460 Signet Drive
   Weston, Ontario
   M9L 2T6

   Contact: Sam Salcitelli

4. Man-Des Industries Inc. — Tel: 671-2406
   190 Highway 7 West
   Unit 34
   Brampton, Ontario
   L7A 1A2

   Contact: Boris Briskin

5. Harrington Tool & Die Co. Ltd. Tel: 421-0544
925 Millwood Road
Toronto, Ontario
M4G 1X4

Contact: John Newman

6. Horn Industries Ltd. Tel: 665-8313
1111 Finch Ave. West
Downsview, Ontario
M3J 2E5

Contact: Walter Horn

7. Lepper & Sons Ltd. Tel: 291-4461
291 Progress Ave.
Scarborough, Ontario
M1T 2Z2

Contact: Mike White

8. Leavens Bros. Ltd. Tel: 678-1234
2555 Derry Road East
Mississauga, Ontario
L4T 1A1

Contact: Ed Baumgartner

9. N.O.W. & Associates Tel: 669-2461
452 Bowes Road
P.O. Box 240
Concord, Ontario
L4K 1B4

Contact: Ave Wilkins

10. Anderson Metals
131 Spinnacre Way
Concord, Ontario
L4K 2T2

Tel: 738-0093

Contact: Nelson Whitehead

Fabricators

1. Acra-Fab
1821 Albion Rd.
Unit 12
Rexdale, Ontario
M9W 5S7

Tel: 675-1126

Contact: Jack Bowman

2. Specialist Weld
2222 South Sheridan Way
Mississauga, Ontario
L5J 2M4

Tel: 823-4080

Contact: Peter Draycott

3. Master Welding
1258 Lakeshore Road East
Mississauga, Ontario
L5E 1H3

Tel: 278-5211

Contact: Ralph Lythgoe

4. Price & Knott
P.O. Box 160
West Hill, Ontario
M1E 4R5

Tel: 284-1616

Contact: Hiromu Fujiki

5. Apollo Sheet Metal Contractors Ltd.
1353 Brittania Road East
Mississauga, Otnario
L4W 1C7

Tel: 671-2215

Contact:

SANDWELL BEAK RESEARCH GROUP

Centrifugal Separating Machine

Final Development Report

Report Number : 4053/R136
February 1985
Copy Number :
D/I 260/BE

DSMA International Inc.
Toronto, Canada

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1. INTRODUCTION

This final report is submitted by DSMA International to Sandwell Beak Research Group as a conclusion to the detail design programme for a Centrifugal Separating Machine.

This report updates the information contained in DSMA Interim Development Report (4053/R114) issued in July, 1984.

The scope of this final report is to

- describe the centrifugal separator detail design
- review the hardware fabrication quotations
- review costs for engineering services
- estimate scale up costs

The manner in which the design concepts were developed is described in previous reports and in the minutes of subsequent design review meetings. These minutes are attached as Appendix A.

2. EQUIPMENT DESCRIPTION

A complete set of detail design drawings for the fabrication and assembly of the centrifugal separating machine are attached as an appendix to this report.

The final arrangement shown on Drawing E4053-100 includes a single separator assembly housed within an insulated containment vessel. These components are supported by a welded base frame which also acts as a mounting support for the 7.5 hp D.C. drive motor.

2.1 Separator Assembly

The separator assembly arrangement is shown on Drawing E4053 - 102.

The 250 mm diameter separator bowl is supported by a cylinder which rotates within a pair of ball bearing assemblies. This rotating support cylinder incorporates a hydraulic cylinder. A piston operating within this cylinder is used to actuate the scraper assembly within the separator bowl. Hydraulic oil is supplied to this cylinder by a rotary joint mounted to the underside of the assembly. A bypass relief valve incorporated in the head of the hydraulic piston permits an increased throughflow of hydraulic oil in order to improve heat removal from the upper end of the cylinder.

Although grease is used to lubricate the bearing assemblies, provision has been included in the design for the future use of an oil lubrication system if required. Oil ports connecting the upper and lower bearings are temporarily plugged when grease lubrication is in use.

External ports in the outer support housing are used to circulate cold water around the upper bearing to aid heat removal from this area. Heat transfer between the separator bowl and support cylinder is minimized by a slab of Vespel insulation sandwiched between these components. Labyrinth seals installed above the upper bearing prevent the ingress of hot corrosive vapours from the containment vessel and these are assisted by the continuous purging of the area between the seals with dry nitrogen.

2.2 Separator Bowl

The separator bowl is rotated at a speed of 4600 rpm in order to separate the solid and liquid constituents of the slurry feed. Slurry is introduced to the bowl by a feed pipe inserted through the lid of the surrounding containment vessel. A scraper assembly which closely matches the internal diameter of the bowl is used to propel deposited solids up the surface of the bowl where they are finally ejected into the containment vessel. The scraper assembly is propelled by the hydraulic actuator below and a peripheral ring on the scraper piston can be easily replaced in the event of excessive abrasive action. Drilled ports in the head of the scraper piston permit trapped liquid to escape the bowl when the centrifugal operation is complete. The contoured design of the scraper and bowl is intended to prevent the permanent migration of solid particles behind the scraper piston.

Liquid take off ports are integrated in a ring installed at the upper edge of the separator bowl. This ring is shaped to permit the easy passage of solids without interfering with the flow of centrifuged liquid to the containment vessel.

2.3 Drive System

Rotation of the separator bowl is achieved by a 7.5 hp D.C. motor mounted externally and driving through a toothed belt and pulley arrangement, with a 1:2 ratio speed reduction at the motor.

Operation of the hydraulic scraper piston is controlled by a hydraulic power pack which supplies oil to the rotating cylinder at pressures up to 2000 psi. Due to the difficulties associated with the installation of sensors within the hydraulic cylinder, scraper piston position is sensed by an external flow measuring device. This sensitive flowmeter accurately measures the flow of oil to or from the cylinder permitting the calibration of the scraper piston position. Actuation of the scraper piston assembly is independent of the separator bowl drive system.

2.4 Containment Vessel

Details of the containment vessel design are shown on Drawings E4053-101 and E4053-103. Centrifuged solids and liquids ejected from the separator bowl are collected in annular tanks within this containment vessel. The lid of the vessel supports a shield used to deflect solids either to a solvent tank or directly into a solids collection hopper. These shields are easily interchanged by removal of the lid assembly, held in place by a Marman style clamp. Windows installed in this lid permit observation of the centrifuge process.

Inlet pipes to the annular solvent tank complete with eductors are used to introduce solvent to the containment vessel and a port is included for the installation of a mixer assembly.

3. HARDWARE FABRICATION

Quotations for fabrication of the Centrifugal Separating Machine were received from several Toronto based machine shops. These are included as Appendix B.

Suppliers of individual fabricated assemblies are as follows:

Centrifugal Separator Details	Horn Industries Ltd. 1111 Finch Avenue West Unit 28 Downsview, Ontario M3J 2E5
Containment Vessel Details	NOW & Associates Inc. 452 Bowes Road P.O. Box 240 Concord, Ontario L4K 1B4
Hydraulic Power Pack	National Hydraulics Ltd. 580 Oster Avenue Concord, Ontario L4K 2C1
Assembly and Balancing	Hawker Siddeley Canada Orenda Division Derry Road East Toronto, Ontario

Individual bought out components were purchased directly by SBRG.

4. ENGINEERING SERVICES

The following is a summary of the costs for engineering services supplied by DSMA International for the detail design of the Centrifugal Separating Machine. These include costs for concept development, detailed engineering, preparation of shop drawings, specifications, fabrication/assembly assistance and scale up estimates.

	Hours	$
Separator Assembly Concepts	167	10,200.00
Containment Vessel Concepts	123.5	7,762.37
Detail Design	1,081.5	54,697.62
Fabrication/Assembly Assistance	52	4,031.18
Scale up Estimate	31	1,758.06
Total -	1,455 hrs	$ 78,449.23

5. SCALE UP ESTIMATE

Following completion of detail design of the pilot plant Centrifugal Separating Machine, estimates were prepared for a scaled up version of the equipment.

These estimates were based upon the actual costs incurred for the fabrication and assembly of the pilot plant equipment adjusted to suit the increased component sizes for the full scale version.

An optimum bowl size was selected assuming a particle acceleration requirement of 3000 g and a cake thickness of 5 mm. In order to maintain bowl material stresses at an acceptable level it was concluded that a suitable bowl diameter would be 950 mm with a corresponding rotation speed of 2440 rev/min.

Scraper piston loads were estimated on the basis of a friction coefficient of 0.5 between the centrifuged cake and the bowl surface. This resulted in an axial scraper load of 40,000 lb, requiring an oil pressure of 4800 psi with the existing 3-1/4" diameter hydraulic piston.

A review of the standard range of Denblin hydraulic rotary unions indicated that although the rotational speed requirement had decreased from 4600 to 2440 rev/min, model "2520,000" installed for the pilot plant operation was still the most appropriate model for the scaled up version.

With a recommended maximum rotary joint operating pressure of 1000 psi, a hydraulic piston diameter of 7" is required to produce the necessary scraper axial force.

This, in turn, would result in increased hydraulic cylinder, separator housing and support bearing diameters.

Hardware estimates for the scaled up version of the centrifugal separator assembly are as follows:

CENTRIFUGAL SEPARATOR ASSEMBLY

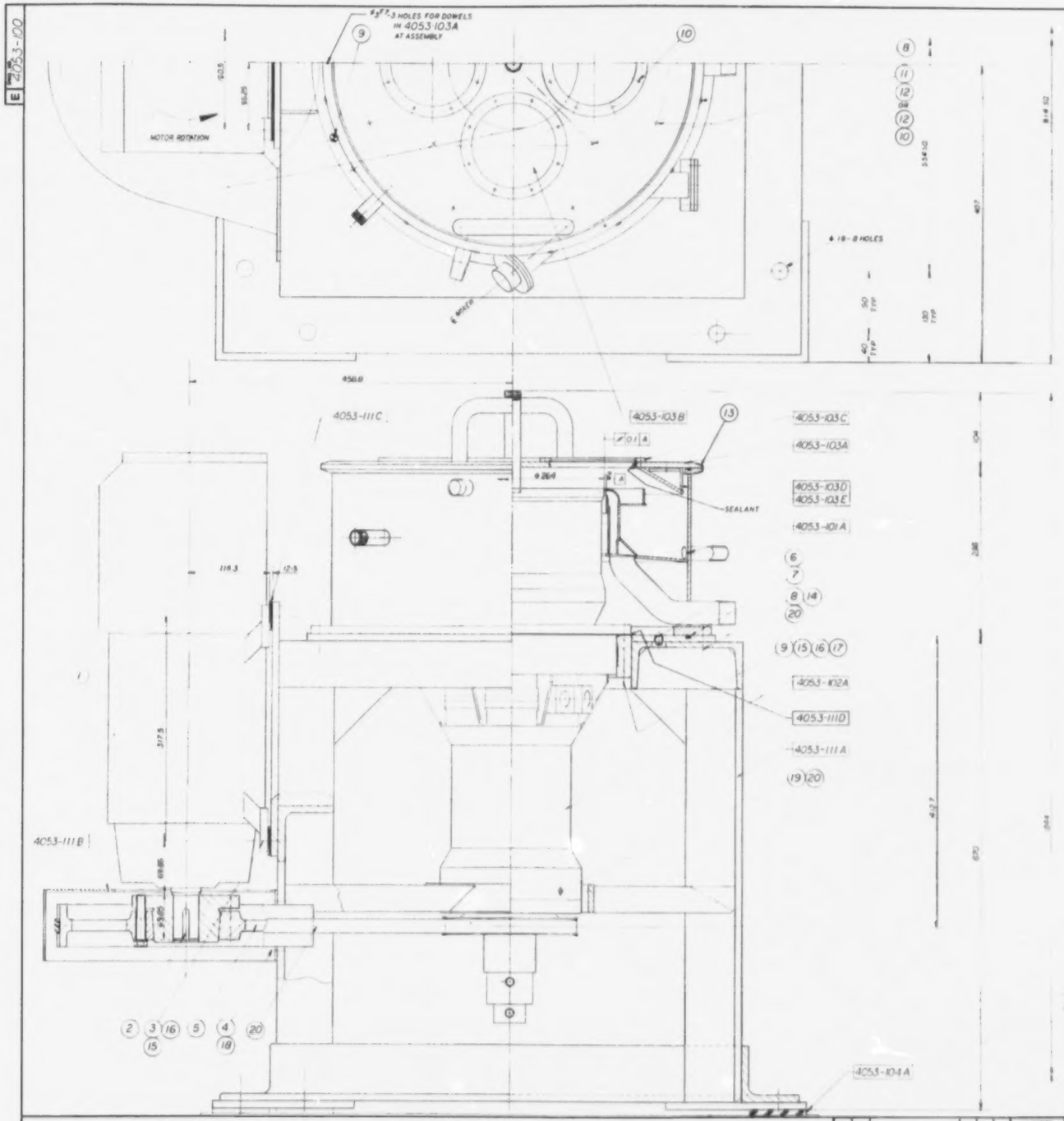
HARDWARE ESTIMATE

Item	Ref	Component	Qty.	Price Per Quantity ($ Cdn) 1-10	10-25	25-50
1	105	Piston Rod/Scraper	1	9,500	8,075	7,125
2	106	Cylinder/Spacers	1	10,400	8,840	7,800
3	107	Separator Details I	1	15,000	12,750	11,250
4	108	Housing Details	1	19,000	16,150	14,250
5	109	Separator Details II	1	4,800	4,080	3,600
6	110	Liquid Take off Port	1	5,500	4,675	4,125
7	1	Deublin Rotary Joint	1	440	440	440
8	2	Lee Plugs	6	25	25	25
9	3	Simmerring Oil Seal	1	102	102	102
10	4	Leepri Valve	1	135	135	115
11	5	Labyrinth Seals	2	1,400	1,200	1,050
12	7	Reena Rod Seal	1	73	64	59
13	8	Reena Rod Seal	1	38	34	30
14	10	Bearings Duplex Pair	1	3,900	2,725	2,425
15	-	Bearing Radial	1	485	485	485
16	11/12	'O' Ring Seals	1	25	25	25
17	18	Drive Belt	1	130	130	130
18	-	Drive Sprocket	1	1,200	1,020	900
19	-	Drive Motor/Controller (200 HP)	1	15,500	13,250	11,600
20	-	Fixings/Fastenings	1	150	130	110
		Hardware Total		87,803	74,335	65,646
		Assembly/Balancing		7,500	6,400	5,600
		Total		95,303	$80,735	$71,246

DRAWINGS

LIST OF DRAWINGS		
DRAWING	ISSUE	TITLE
E4053-100	1	Centrifugal Separator - General Assembly
E4053-101	1	Solvent Tank Weldment
E4053-102	1	Separator Assembly
E4053-103	1	Solvent Tank Cover Details
E4053-104	1	Centrifugal Separator Base Frame
E4053-105	1	Piston Rod & Scraper Details
E4053-106	1	Cylinder and Spacer Details
E4053-107	1	Separator Details I
E4053-108	1	Housing Detail
E4053-109	1	Separator Details II
E4053-110	1	Liquid Take Off Port Detail
E4053-111	1	Centrifugal Support Frame
E4053-112	1	Hydraulic Schematic

E 4053-100



ITEM NO.	REFERENCE DWGS.

BILL OF MATERIAL

ITEM	QTY.	DESCRIPTION	MATERIAL	WEIGHT	REF.
	1	D.C. MOTOR FRAME B (811.62") TYPE TEFC 7.5 HP 2500 RPM		5	7.1
2	1	KEY 10 .312" x 1.75"	ST		
3	4	HX HD SCR M10 x 55 DIN 933	GR 8.8		
4	6	HX HD SCR M8 x 16 DIN 933	ST		
5	1	UNIVERSAL MADE TO ORDER SPROCKET FOR 8mm PITCH HTD BELT 44 GROOVES, 50mm WDTH, 2500 RPM, 14.43" P.D., BUSHING STYLE "E" BORED TO SUIT 1.06" SHAFT WITH 5/16 SQ. KEY	ST	3	2.0
6	1	PLUG 1/8 NPT			
7	2	O-RING SAE NO. AS 568-466	VITON		
8	16	HX HD SCR M8-45 DIN 931	GR 8.8		
9	4	PARALLEL PIN 1/4" x 1.50 DIN 7	ST		
10	44	CSK HD SCR M5 x 12 DIN 7991	GR 8.8		
11	12	HX HD SCR M5 x 16 DIN 933			
12	12	HX NUT M5 DIN 934	GR 8		
13	1	LATCH HARDWARE B2.1.2.50	STAINLESS STEEL	0	
14	16	HX NUT M8 DIN 934	GR 8		
15	12	HX NUT M10 DIN 934			
16	12	LOCKWASHER M10 DIN 127	ST		
17	8	HX HD SCR M10 x 30 DIN 931	GR 8.8		
18		UNIVERSAL 8mm PITCH x 10" BELT 1600 LENGTH, 32mm WIDTH			
19	4	HX HD SCR M8 x 20 DIN 933	GR 8.8		
20	24	LOCKWASHER M8 DIN 127	ST		

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETRES EXCEPT WHERE NON DIMENSIONS ARE SPECIFIED THUS *
2. ALL SIZES GIVEN ARE FINISHED OVERALL. MACHINING AND TRIMMING ALLOWANCES SHALL BE DETERMINED BY FABRICATOR.
3. UNLESS OTHERWISE SPECIFIED ALL SCREW THREADS SHALL HAVE STANDARD COARSE PITCH AND A CLASS 6g/6H FIT.
4. LOCTITE SEALANT GRADE AV SHALL BE APPLIED TO FASTENER THREADS WHERE MECHANICAL LOCKING IS IMPRACTICABLE.
5. RELIANCE ELECTRIC LTD.
6. AEROQUIP (CANADA) LTD. 247 BRIDGELAND AVE. TORONTO ONT. M6A 1Z7

CENTRIFUGAL SEPARATOR 4053-100A
ONE REQ'D.
TOTAL EST. WEIGHT 330 kg

Sandwell Beak Research Group
Centrifugal Separating Machine

© SANDWELL AND COMPANY LIMITED 1984

NO.	BY	REVISION	DATE
1	RM	AS DRAWN	84 08 28

CENTRIFUGAL SEPARATOR
GENERAL ASSEMBLY

DSMA International Inc.
Engineers and Constructors
Toronto, Canada

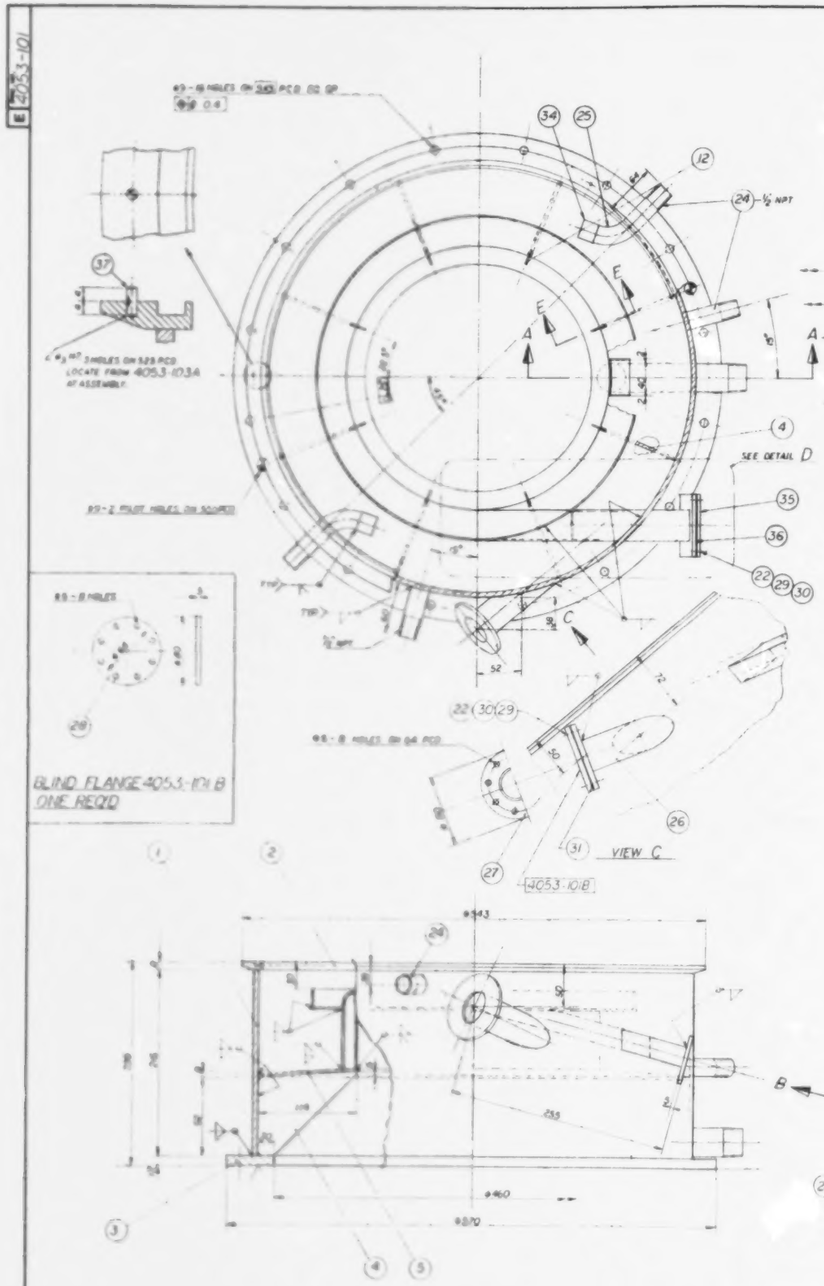
PROJECT	SUFFIX	SIZE	DWG. NO.	SHEET
4053		E	4053-100	1

E 4053-101

DWG. NO.	REFERENCE DWGS.
4053-100	CENTRIFUGAL SEPARATOR GEN. ASS'Y.

BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	MATERIAL	NOTE	WT
1	1	216 x 5 x 1586.5			13
2	1	Ø 543 Ø 490 x 8			3
3	1	Ø 570 X Ø 460 x 12			8
4	8	100 x 5 x 114			1
5	1	IRREGULAR SHAPE x 4			4
6	1	Ø 382 X Ø 308 x 2			1
7	1	21 x 2 x 1181			1
8	1	67.5 x 2 x 960 R			1
9	1	R 16 x 3 x 952			2
10	1	IRREGULAR SHAPE x 2			
11	1	25 x 2 x 948.2			
12	9	16 x 2 x 18			
13	2	23 x 2 x 24	STAINLESS STEEL TYP 316		
14	1	32 x 2 x 40			
15	1	1" SCH 40 PIPE x 62 LG			
16	1	IRREGULAR SHAPE x 2			
17	1	36 x 2 x 295			
18	1	IRREGULAR SHAPE X 2			
19	1	36 x 2 x 149			
20	1	34 x 2 x 61			
21		7 x 2 x 34			
22	16	LOCK WASHER AS DIN 127			
23	1	60 x 5 x 66			
24	4	PIPE 1/2" SCH 40 x 54 LG			
25	2	1/2" SCH 40 - 45° ELBOW			13
26		PIPE SCH 40 1/2" TO SUIT			
27		3 9" x 12			
28		3 9" x 12			
29	16	HEX SCREW M5x20 LG DIN 933			
30	16	HEX NUT M5 DIN 934			
31		GASKET	1/16" THICK STAINLESS TYP 316		
32		1" SCH 40 PIPE x 79 LG			
33	2	1" SCH 40 - 45° ELBOW			13
34	2	1" SCH 40 HALF COUPLING			
35		60 x 5 x 66 BLIND FLANGE			
36	1	GASKET	1/16" THICK RUBBER		
37	3	Ø 16 x 8 DOWEL DIN 7	STAINLESS TYPE 316		



BLIND FLANGE 4053-101 B ONE REQ'D

SOLVENT TANK 4053-101A ONE REQ'D
EST. WEIGHT 37 Kg

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETRES EXCEPT WHERE INCH DIMENSIONS ARE SPECIFIED THUS ●
2. TOLERANCES TO BE NON-ACCUMULATIVE.
3. UNLESS OTHERWISE SPECIFIED, TOLERANCES ON DIMENSIONS SHALL BE AS FOLLOWS:

		UNMACHINED WORK	MACHINED WORK
	≤ 50	±0.5	±0.075
> 50	≤ 250	±1.0	±0.15
> 250	≤ 500	±1.5	±0.25
> 500	≤ 1000	±2.0	±0.5
> 1000	≤ 6000	±4.0	±1.5
ANGLES		±0.5°	AS NOTED

4. UNLESS OTHERWISE SPECIFIED, MACHINED SURFACE FINISHES SHALL BE 3.2 MICRONS OR BETTER (ARITHMETICAL MEAN).
5. BREAK ALL SHARP CORNERS AND EDGES.
6. UNLESS OTHERWISE SPECIFIED, FILLET RADII SHALL BE MIN. 0.2 MAX. 0.5
7. ALL SIZES GIVEN ARE FINISHED OVERALL; MACHINING AND TRIMMING ALLOWANCES SHALL BE DETERMINED BY FABRICATOR.
8. UNLESS OTHERWISE SPECIFIED, ALL SCREW THREADS SHALL HAVE STANDARD COARSE PITCH AND A CLASS 6g/6H FIT.
9. LOCTITE SEALANT GRADE AV SHALL BE APPLIED TO FASTENER THREADS WHERE MECHANICAL LOCKING IS IMPRACTICABLE.
10. ALL WELD SYMBOLS ARE IN ACCORDANCE WITH THE CSA STANDARD W47.
11. ALL WELDMENTS SHALL BE STRESS RELIEVED BEFORE MACHINING.
12. ALL GUSSETS TO BE CHAMFERED TO CLEAR CORNER WELDS.
13. SEAMLESS WELDING FITTING

Sandwell Beak Research Group
Centrifugal Separating Machine

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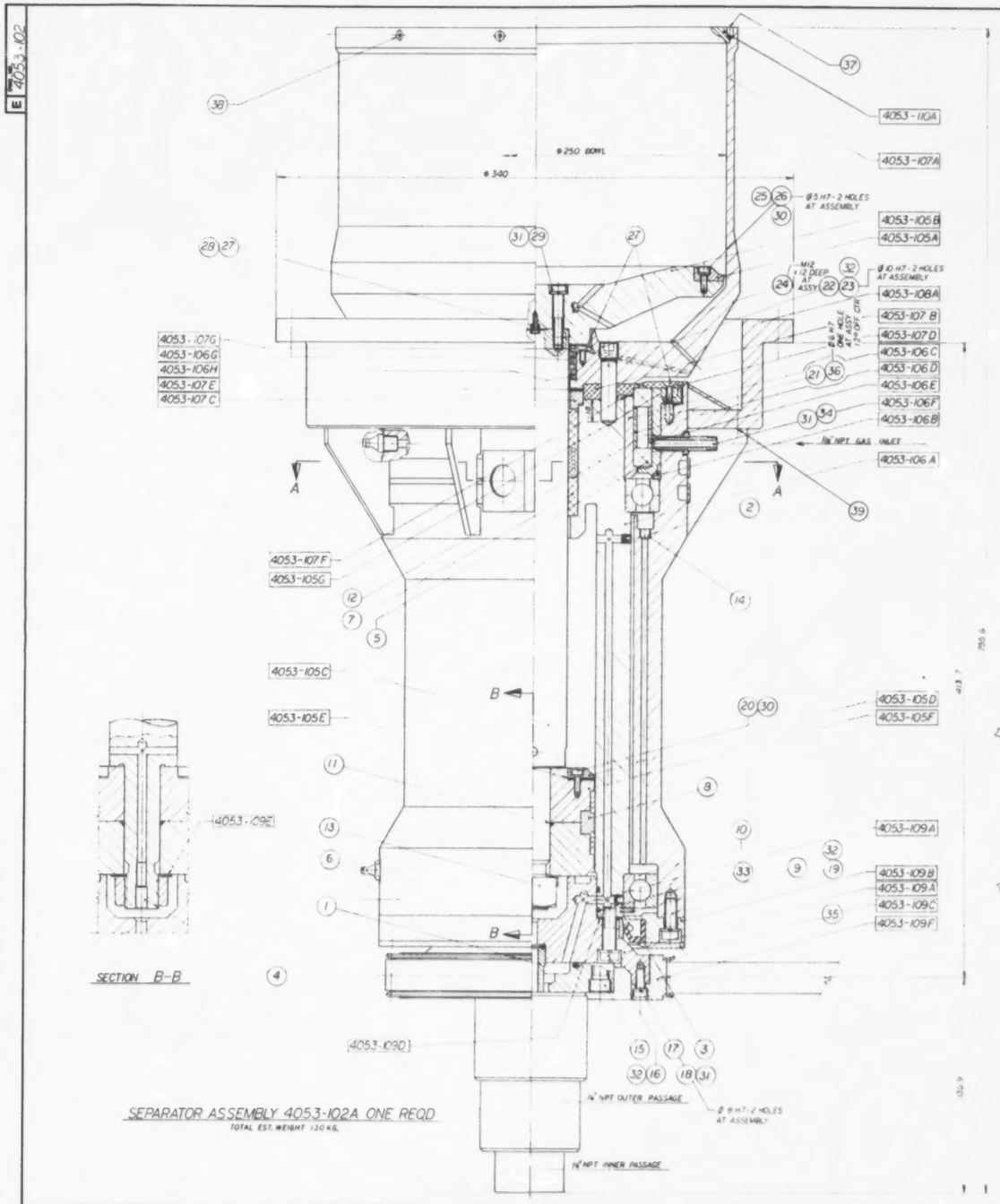
REVISION	PROJECTION	SOLVENT TANK WELDMENT
L BR AS DRAWN	THIRD ANGLE	
DESIGNED P.D. DRAWN B. CHECKED APPROVED	P. DUGGAN	

DSMA International Inc.
Engineers and Constructors
Toronto, Canada

PROJECT	SECTION	SIZE	DWG. NO.	REV.
4053		E	4053-101	1

E 4053-102



SEPARATOR ASSEMBLY 4053-102A ONE REQD
TOTAL EST. WEIGHT 130 KG.

THIS NO.	REFERENCE DATA
4053 ₵D	CENTRIFUGAL SEPARATOR GENERAL ASSEMBLY

NOTES CONT'D

11 DISCORN INDUSTRIES OF CANADA LTD 5574 TOMKEN RD MISSISSAUGA, ONTARIO L4W 1P4

12 ALL FASTENERS AND PINS TO BE COATED WITH MOLYB DENUM DISULPHIDE BEFORE FINAL ASSEMBLY.

13 REENA PACKING & SEAL PRODUCTS LTD 640 PETROL A Rd DOWNSVIEW ONTARIO M3J 2W3

14 CANADIAN BEARINGS INC 310 AMERICAN DRIVE MISSISSAUGA, ONTARIO

15 STANCCO CANADA LTD 29 FENGAR DRIVE WESTON, ONTARIO M9L 1L4

BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	MATERIAL	NOTE	WT
1	1	DEUBLIN DEU-PLEX ROTATING UNION MODEL 2520-000	SEE	9	27
2	6	LEE PLUG NO PLSM 065 00 20 CLASS 3	STAINLESS STEEL	10	—
3	1	OIL SEAL SAMMERING ø120×ø150×13 B2		11	—
4	1	LEEPAK 281 VALVE NPT PARA 281-2 500 1	STAINLESS STEEL	10	—
5	2	SPECIAL LABYRINTH SEAL 4.55"ø × 4.30"ø × 12	—	—	—
6	2	GREASE FITTING 1/8" NPT	ST	—	—
7	1	REENA PACKING NO 41C27-100	—	13	—
8	1	REENA PACKING NO HC 20041	—	13	—
9	1	TRIJARC RET RING 300 47"ø H	STAINLESS STEEL	14	—
10	2	MAC NO 1338 S GASKET 7.5" ø INSIDE	SILICONE RUBBER	14	25
11	1	SIMRIT 'D' RING ø 23 × 2	SYNTHETIC RUBBER	11	—
12	1	" " ø 19 × 2	SYNTHETIC RUBBER	11	—
13	1	5/8"–18 UNF HX NU	SAE GR5	—	—
14	6	3/8 SET SCR CONE PT WITH S.A.	SE	—	—
15	4	1/4×20C SCR SOCKET HEAD CAP	SAE GR8	—	—
16	6	LOW HD HX SOCK M8 30 DIN 7984	SR 10-9	15	—
17	9	" " " M6 6 DIN 7984	"	"	—
18	2	PARALLEL PIN ø6m6 × 24 DIN 7	ST	—	—
19	6	LOW HD HX SOCK M8 DIN 7984	SR 10-9	15	—
20	6	" " " M10×20 DIN 7984	"	"	—
21	9	" " " M6 × 16 DIN 7984	"	"	—
22	8	" " " M8 40 DIN 7984	"	"	—
23	2	PARALLEL PIN 10m6 × 40 DIN 7	ST	—	—
24	6	SOCK SET SCR M12 × 1 × 16 DIN 916	SR 10-9	—	—
25	2	LOW HD HX SOCK M4×0.7 DIN 7984	SR 10-9	15	—
26	7	PARALLEL PIN 5m6 × 10 DIN 7	ST	—	—
27	—	COUNTERSUNK FLAT HD MP SCR M3×10 DIN 7991	SR 10-9	15	—
28	—	PARALLEL KEY A 6×6.5 × 16 DIN 6885	SR 8-M	—	—
29	9	LOW HD HX SOCK M 35 DIN 7984	SR 10-9	15	—
30	1	LOCK WASHER DIN 7980 ø 8	STAINLESS STEEL	—	—
31	—	" " ø 6	"	—	—
32	24	" " ø 8	"	—	—
33	2	WRIT O RING ø84 × 3	SYNTHETIC RUBBER	11	—
34	1	HX HD SOCK M6 × 12 DIN 933	SR 10-9	15	—
35	9	" HD CAP SCR M4 × 25 DIN 7991	SR 10-9	15	—
36	—	PARALLEL PIN 4 m6 × 40 DIN 7	ST	—	—
37	—	" " 4 m6 × 8	SE	—	—
38	2	WRIT O RING ø84 × 3	SR 10-9	8	—
39	1	3/4-27 NPTF PIPE PLUG	SE	—	—

NOTES

1 ALL DIMENSIONS ARE IN MILLIMETRES EXCEPT WHERE INCH DIMENSIONS ARE SPECIFIED THUS *

2 TOLERANCES TO BE NON-ACCUMULATIVE.

3 UNLESS OTHERWISE SPECIFIED, TOLERANCES ON DIMENSIONS SHALL BE AS FOLLOWS:

		UNMACHINED WORK	MACHINED WORK
	≤ 50	±0.5	±0.075
> 50	≤ 250	±1.0	±0.15
> 250	≤ 500	±1.5	±0.25
> 500	≤ 1000	±2.0	±0.5
> 1000	≤ 6000	±4.0	±1.5
ANGLES		±0.5°	AS NOTED

4 UNLESS OTHERWISE SPECIFIED, ALL SCREW THREADS SHALL HAVE STANDARD COARSE PITCH AND A CLASS 6g 6H FIT.

5 LOCTITE SEALANT GRADE AV SHALL BE APPLIED TO FASTENER THREADS WHERE MECHANICAL LOCKING IS IMPRACTICABLE.

6 ALL COMPONENT PARTS IN ITEM (3) SHALL BE INDIVIDUALLY BALANCED DYNAMICALLY IN ACCORDANCE WITH ISO 1940 GRADE 2.5 TO BALANCE QUALITY GRADE 1.0 AT A OPERATIONAL SPEED OF 5000 RPM

7 PRIOR TO INSTALLATION BEARING SURFACES ARE TO BE THOROUGHLY CLEANED WITH SOLVENTS AND OTHER SUITABLE TECHNIQUES BEFORE FINAL LUBRICATION WITH UNIREX N3 GREASE BY MOBIL OIL CO.

8 TIGHTENING TORQUES FOR BOLTS

THREAD	STRENGTH	TORQUE
M5	GR 10.9	20 kg cm
M6	"	45 "
M8	"	145 "
M10	"	371 "
3/8"-16	SAE GR 5	550 Lb. in.
7/16"-14	GR 5	394 Lb.

UNLESS

9 KINEMATIC INDUSTRIAL EQUIPMENT LTD 139 BERMONDSEY RD TORONTO ONT M4A 1X3

10 THE LEE CO 2 PETTIBONE RD ALGONQUIN ILLINOIS 60102 USA

Sandwell Beak Research Group
Centrifugal Separating Machine

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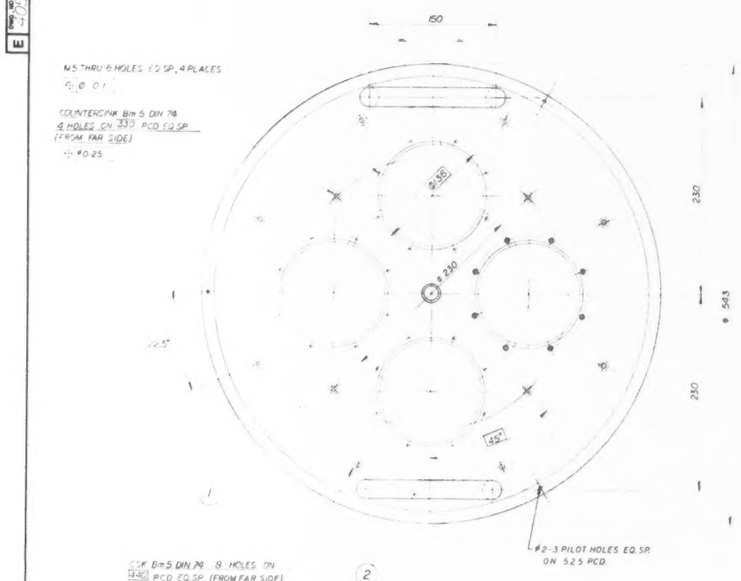
REVISION					
J	JM	AS DRAWN			

SEPARATOR ASSEMBLY

DSMA International Inc.
Engineers and Constructors
Toronto, Canada

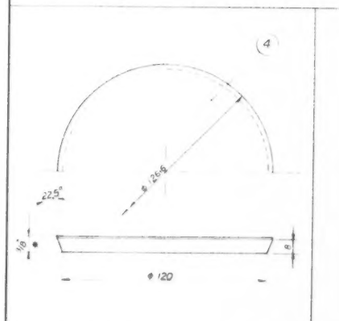
PROJECT	SECTION	SIZE	DWG. NO.	ISSUE
4053		E	4053-102	1

E DWG. NO. 4053-103



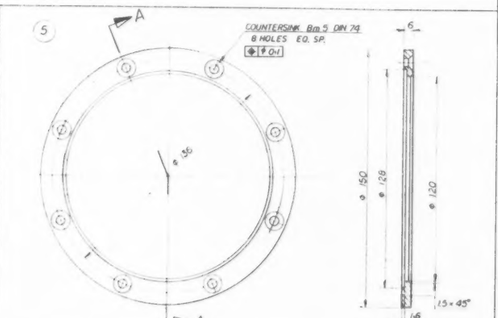
COVER 4053-103 A ONE REQ'D

SCALE 1 2



WINDOW 4053-103 B 4 REQ'D

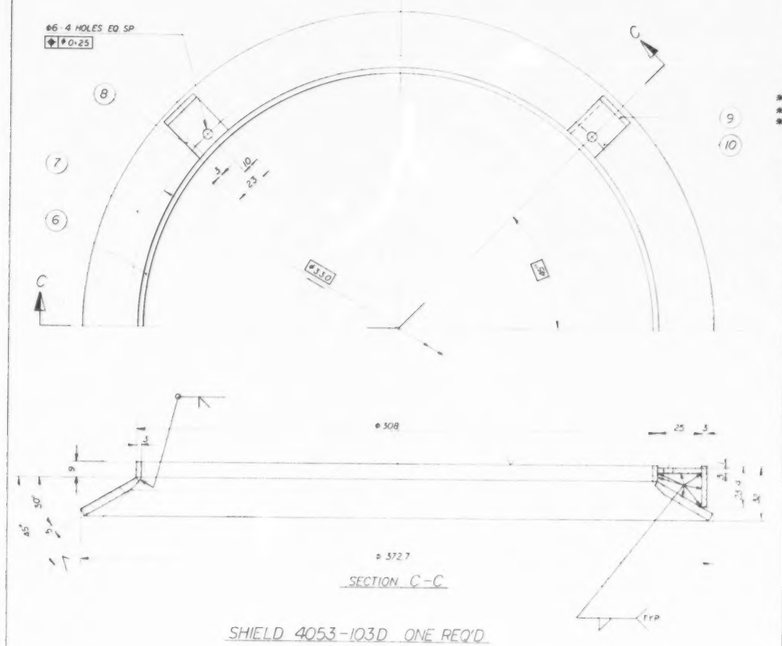
SCALE FULL



WINDOW FRAME 4053-103 C 4 REQ.

SECTION A-A

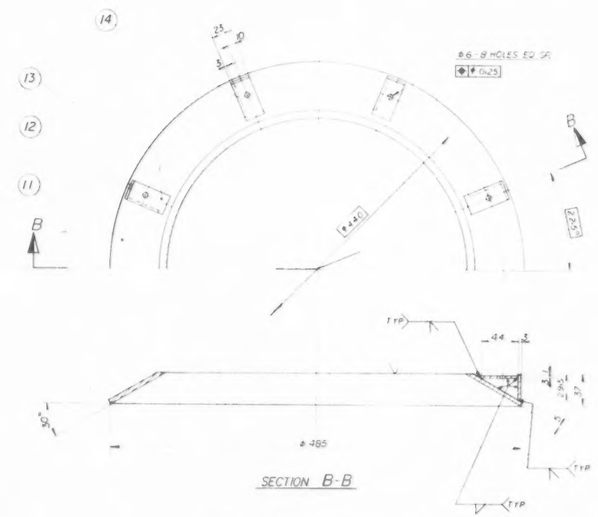
SCALE FULL



SECTION C-C

SHIELD 4053-103 D ONE REQ'D

SCALE FULL



SECTION B-B

SHIELD 4053-103 E ONE REQ'D

SCALE 1 2

DWG. NO.	REFERENCE DWGS.
4053-100	CENTRIFUGAL SEPARATOR GEN ASS'Y

BILL OF MATERIAL

ITEM	QTY.	DESCRIPTION	MATERIAL	NOTE	WT.
1	1	Ø543 x 8	ST. SPANT 316		12
* 2	2	1/2 SCH 40 PIPE x 285	"		1
* 3	1	" x 140	"		
* 4	4	9 126.6 x 3/8	PHASE 2/4788		1
5	4	Ø 150 x 9 120 x 6	ST. SPANT 316		1
6	1	9 x 3 x 956	"		—
7	1	IRREGULAR SHAPE - 5	"		2
8	4	19 x 3 x 25	"		—
9	4	25 x 5 x 25.4	"		—
10	4	25 x 3 x 25	"		—
11	1	IRREGULAR SHAPE - 5	"		1
12	8	25 x 3 x 285	"		—
13	8	25 x 3 x 44	"		—
14	9	25 x 3 x 40	"		—

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETRES EXCEPT WHERE INCH DIMENSIONS ARE SPECIFIED THUS *
2. TOLERANCES TO BE NON-ACCUMULATIVE.
3. UNLESS OTHERWISE SPECIFIED, TOLERANCES ON DIMENSIONS SHALL BE AS FOLLOWS:

		UNMACHINED WORK	MACHINED WORK
	≤ 50	± 0.5	± 0.075
> 50	≤ 250	± 1.0	± 0.15
> 250	≤ 500	± 1.5	± 0.25
> 500	≤ 1000	± 2.0	± 0.5
> 1000	≤ 6000	± 4.0	± 1.5
ANGLES		± 0.5°	AS NOTED

4. UNLESS OTHERWISE SPECIFIED, MACHINED SURFACE FINISHES SHALL BE 3.2 / MICRONS OR BETTER (ARITHMETICAL MEAN).
5. BREAK ALL SHARP CORNERS AND EDGES.
6. UNLESS OTHERWISE SPECIFIED, FILLET RADII SHALL BE MIN. 0.2 MAX. 0.7
   ALL SIZES GIVEN ARE FINISHED OVERALL. MACHINING AND TRIMMING ALLOWANCES SHALL BE DETERMINED BY FABRICATOR.
7. UNLESS OTHERWISE SPECIFIED, ALL SCREW THREADS SHALL HAVE STANDARD COARSE PITCH AND A CLASS 6g/6H FIT.
8. ALL WELD SYMBOLS ARE IN ACCORDANCE WITH THE CSA STANDARD W47.1
9. ALL WELDMENTS SHALL BE STRESS RELIEVED BEFORE MACHINING.
10. ALL GUSSETS TO BE CHAMFERED TO CLEAR CORNER WELDS.

Sandwell Beak Research Group
Centrifugal Separating Machine

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ISSUE	BY	REVISION	DATE	APPVD
1	BM	AS DRAWN	84	

PROJECTION: THIRD ANGLE
DESIGNED
DRAWN B
CHECKED
APPROVED

P DUGGAN

SOLVENT TANK COVER DETAILS

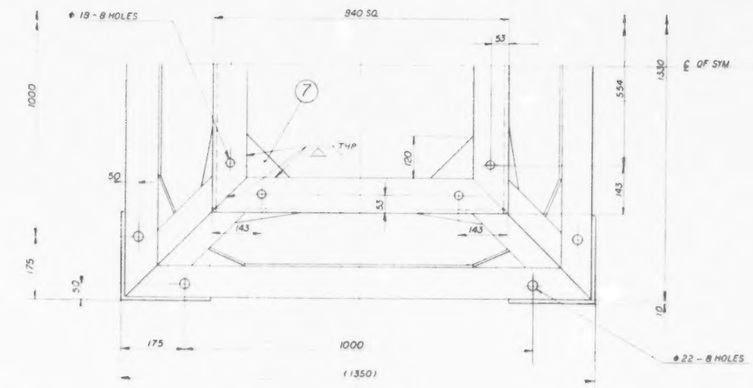
DSMA International Inc.
Engineers and Constructors
Toronto, Canada

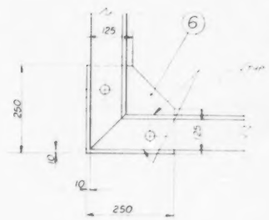
SCALE 1 1 & 1 2 | SHEET 1 OF 1 SHEETS

PROJECT	SECTION	SIZE	DWG. NO.	ISSUE
4053		E	4053-103	1

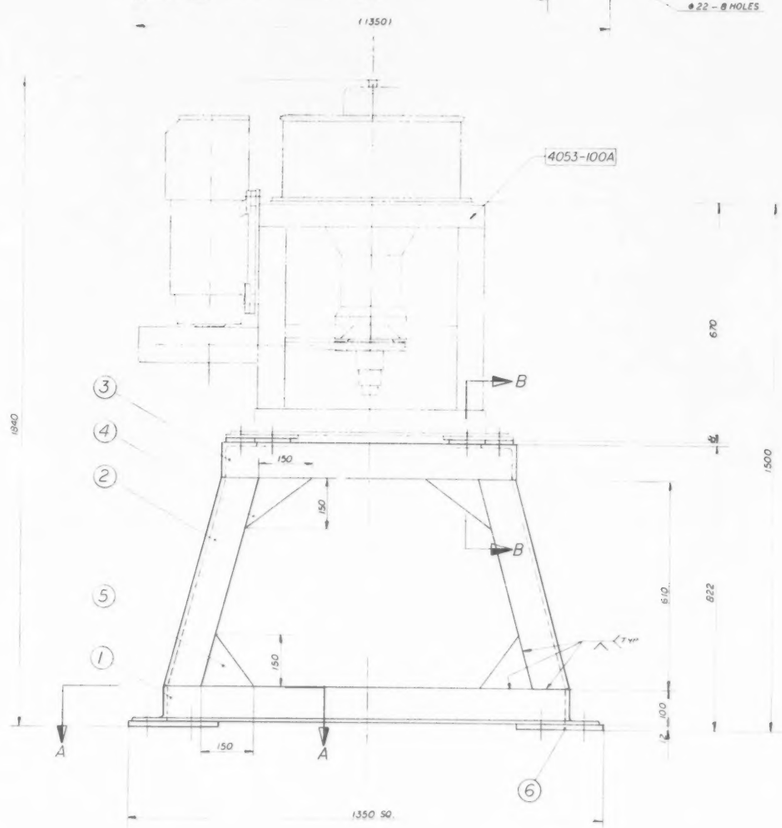
DWG. NO. 4053-104

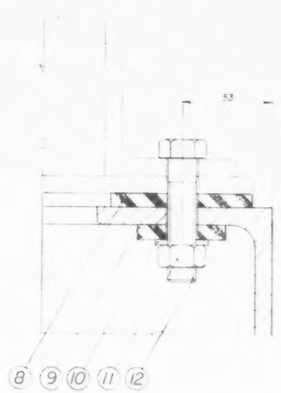
E





SECTION A-A





SECTION B-B
SCALE 1 : 1

BASE FRAME 4053-104 A ONE REQ'D

EST WEIGHT BASE FRAME 205 Kg

DWG. NO.	REFERENCE DWGS.
4053-100	CENTRIFUGAL SEPARATOR GEN. ASSY.

BILL OF MATERIAL

ITEM	QTY.	DESCRIPTION	MATERIAL	NOTE	WT.
1	4	L 100 × 100 × 10 × 1330	ASTM A 36		79
2	4	" " × 655	"		39
3	4	" " × 1040	"		50
4	9	150 × 10 × 188	"		2
5	9	150 × 10 × 150	"		2
6	4	250 × 12 × 250	"		21
7	4	120 × 10 × 120	"		2
8	8	FABREEKA 90 × 9 × 90	FABREEKA 90		
9	9	" 65C × 9 × 9	"		
10	9	WASHER A 17 DIN 125	ST.		
11	9	HEX NUT M16 DIN 934	GR. 8		
12	8	HX HD SCR M16 × 70 DIN 931	GR. 8.8		

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETRES EXCEPT WHERE INCH DIMENSIONS ARE SPECIFIED THUS: "
2. TOLERANCES TO BE NON-ACCUMULATIVE.
3. UNLESS OTHERWISE SPECIFIED, TOLERANCES ON DIMENSIONS SHALL BE AS FOLLOWS:

		UNMACHINED WORK	MACHINED WORK
> 50	≤ 50	± 0.5	± 0.075
> 250	≤ 250	± 1.0	± 0.15
> 500	≤ 500	± 1.5	± 0.25
> 1000	≤ 1000	± 2.0	± 0.5
	≤ 6000	± 4.0	± 1.5
ANGLES		± 0.5°	AS NOTED

4. UNLESS OTHERWISE SPECIFIED, MACHINED SURFACE FINISHES SHALL BE 3.2 MICRONS OR BETTER (ARITHMETICAL MEAN).
5. BREAK ALL SHARP CORNERS AND EDGES.
6. UNLESS OTHERWISE SPECIFIED, FILLET RADII SHALL BE MIN. 0.2 MAX. 0.7
7. ALL SIZES GIVEN ARE FINISHED OVERALL, MACHINING AND TRIMMING ALLOWANCES SHALL BE DETERMINED BY FABRICATOR.
8. UNLESS OTHERWISE SPECIFIED, ALL SCREW THREADS SHALL HAVE STANDARD COARSE PITCH AND A CLASS 6g/6H FIT.
9. LOCTITE SEALANT GRADE AV SHALL BE APPLIED TO FASTENER THREADS WHERE MECHANICAL LOCKING IS IMPRACTICABLE
10. ALL WELDS SYMBOLS ARE IN ACCORDANCE WITH C.S.A. STANDARD W 47.1
11. UNLESS OTHERWISE SPECIFIED, ALL BUTT WELDS SHALL BE CONTINUOUS AND OF 100% PENETRATION AND FILLET WELDS SHALL BE FULL STRENGTH AND CONTINUOUS.
12. ALL GUSSETS TO BE CHAMFERED TO CLEAR CORNER WELDS.

Sandwell Beak Research Group
Centrifugal Separating Machine

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1	BM	AS DRAWN			
ISSUE	BY	REVISION	DRWN	APPVD	DATE

PROJECTION: THIRD ANGLE
DESIGNED
DRAWN D. M.
CHECKED
APPROVED

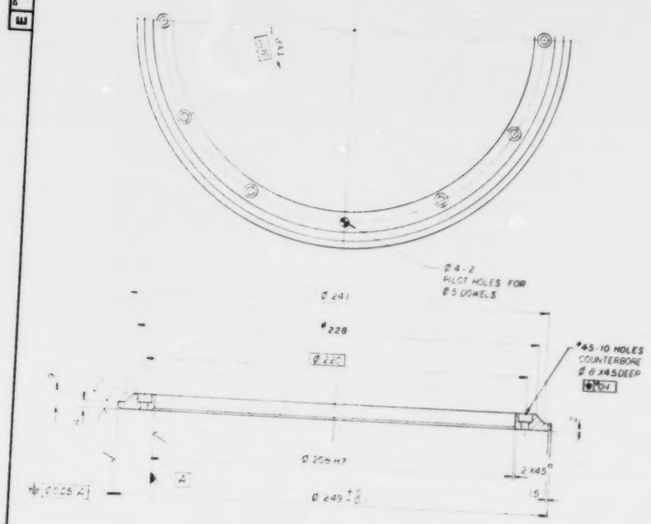
P. DUGGAN

CENTRIFUGAL SEPARATOR

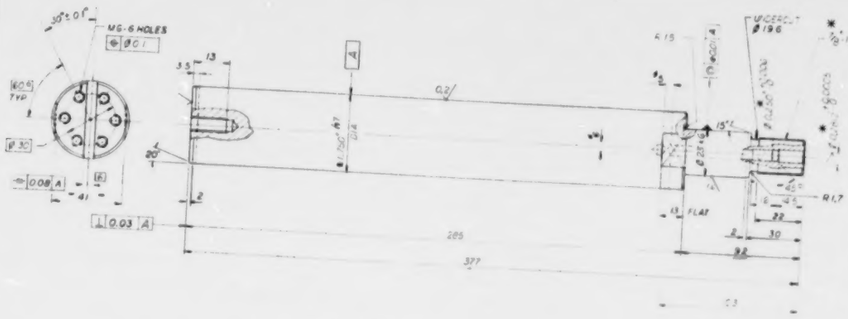
BASE FRAME

DSMA International Inc.
Engineers and Constructors
Toronto, Canada

SCALE 1 : 5 & 1 : 1	SHEET 1 OF 1 SHEETS
PROJECT 4053	SECTION
SIZE E	DWG. NO. 4053-104
ISSUE 1	



① SCRAPER INSERT 4053-105A ONE REQ'D



③ PISTON ROD 4053-105C ONE REQ'D
CONDITION H1150

DWG. NO.	REFERENCE DWGS.
4053-102	SEPARATOR ASSEMBLY

BILL OF MATERIAL

ITEM	QTY.	DESCRIPTION	MATERIAL	NOTE NO.
1		Ø 242 x 9	STAINLESS TYPE 316	1
2		Ø 244 x 6		6
3		Ø 342 x 37*	STAINLESS TYPE 316	4
4		Ø 8 x 7		
5		Ø 5 x M5*	STAINLESS TYPE 316	
6		Ø 8 x 35		2
7		Ø 193 x 3		

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETRES EXCEPT WHERE INCH DIMENSIONS ARE SPECIFIED THUS *
2. TOLERANCES TO BE NON-ACCUMULATIVE.
3. UNLESS OTHERWISE SPECIFIED, TOLERANCES ON DIMENSIONS SHALL BE AS FOLLOWS:

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> 50	≤ 50	±0.5	±0.075
> 250	≤ 250	±1.0	±0.15
> 500	≤ 500	±1.5	±0.25
> 1000	≤ 1000	±2.0	±0.5
	≤ 6000	±4.0	±1.5
ANGLES		±0.5°	AS NOTED

4. UNLESS OTHERWISE SPECIFIED, MACHINED SURFACE FINISHES SHALL BE 3.2 MICRONS OR BETTER (ARITHMETICAL MEAN).
5. BREAK ALL SHARP CORNERS AND EDGES.
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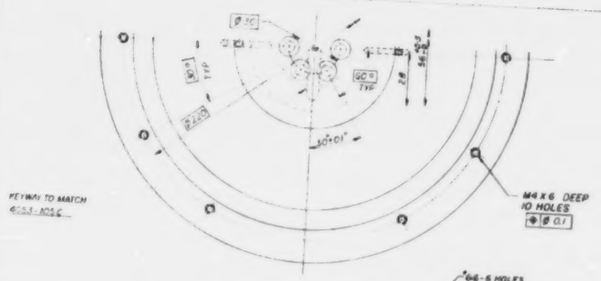
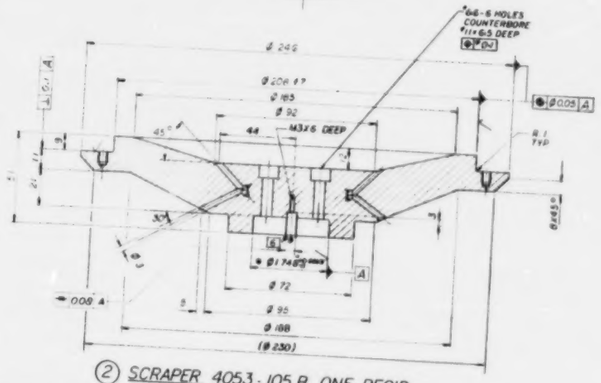
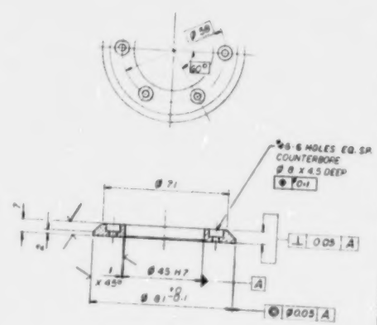
8. UNLESS OTHERWISE SPECIFIED, ALL SCREW THREADS SHALL HAVE STANDARD COARSE PITCH AND A CLASS 6g/6H FIT.





② SCRAPER 4053-105B ONE REQ'D



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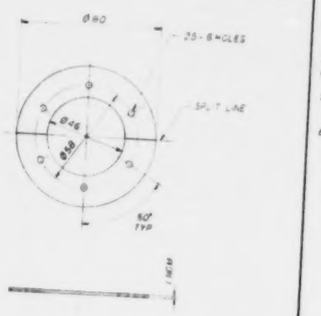

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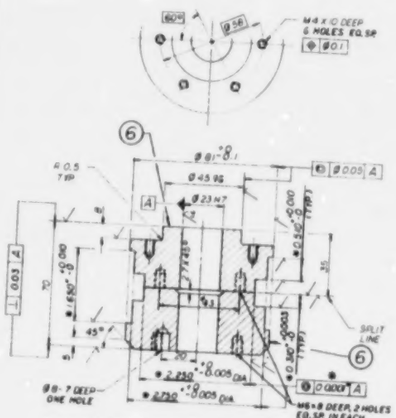
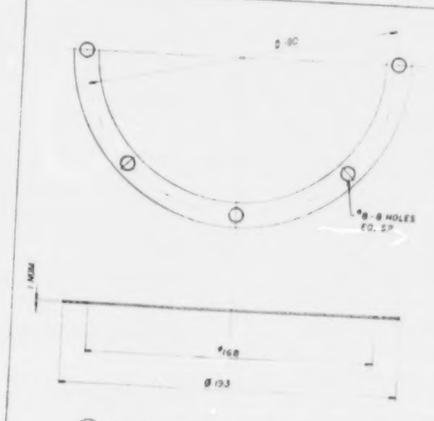


PISTON 4053-105F ONE REQ'D



⑦ SHIM 4053-105G ONE REQ'D

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REVISION	BY	CHECKED	APPROVED
1 SW AS DRAWN			

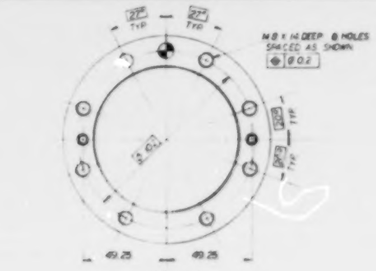
PISTON ROD & SCRAPER DETAILS

Sandwell Beak Research Group
Centrifugal Separating Machine

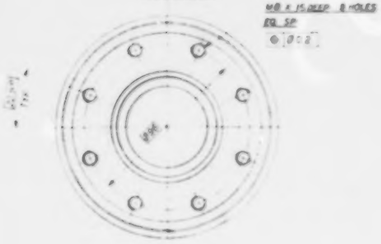
DSMA International Inc.
Engineers and Constructors
Toronto, Canada

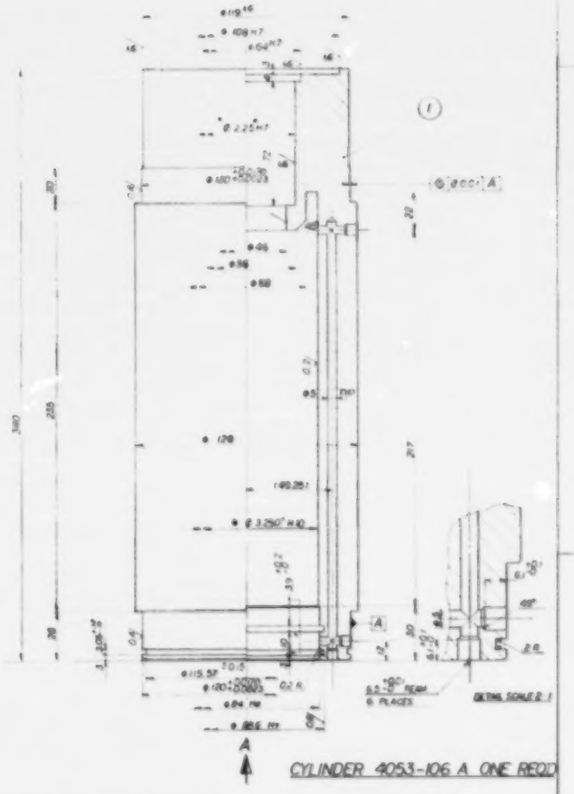
PROJECT	SECTION	SIZE	DWG. NO.	ISSUE
4053		E	4053-105	1

E 4053-106

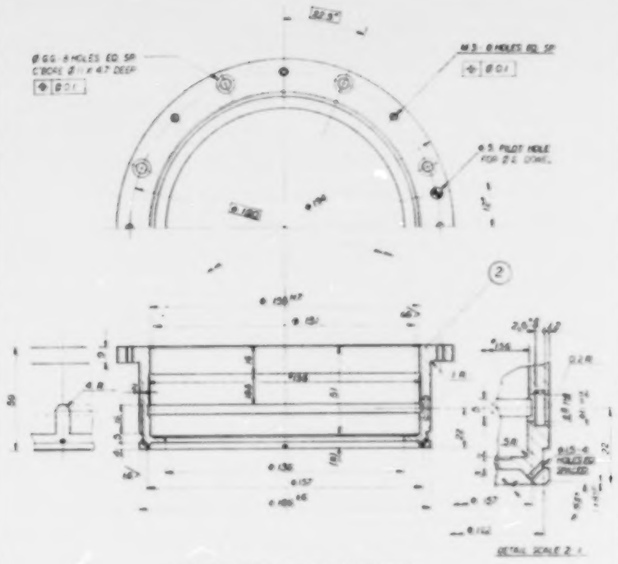


VIEW A

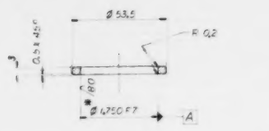




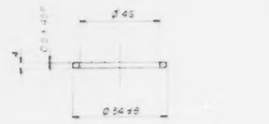
CYLINDER 4053-106 A ONE REQD



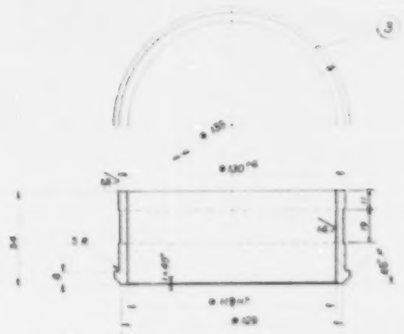
SPACER 4053-106 B ONE REQD



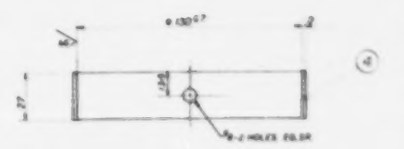
(9) BUSHING 4053-106H 3 REQD



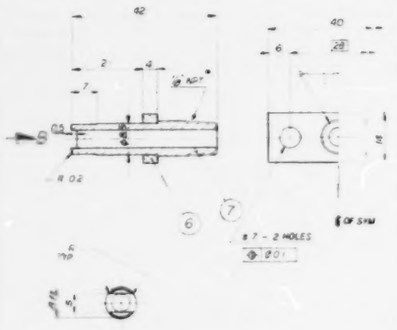
(8) SPACER 4053-106G 2 REQD



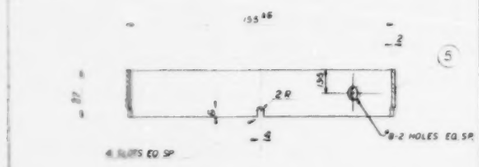
SPACER 4053-106 C ONE REQD



SPACER 4053-106 D ONE REQD



GAS INLET 4053-106 F ONE REQD
SCALE 2:1



SPACER 4053-106 E ONE REQD

DWG. NO.	REFERENCE DWGS.
4053-02	SEPARATOR ASSEMBLY

BILL OF MATERIAL

ITEM	QTY.	DESCRIPTION	MATERIAL	NOTE	WT
1	1	Ø 128 × 340			7.6
2	1	Ø 194 × 59			2
3	1	Ø 135 × 54			1
4	1	Ø 134 × 2	STAINLESS STEEL TYPE 316		–
5	1	Ø 156 × 27			–
6	1	1/4 × 4 × 40			–
7	1	1/8 ISO RC 1/2		*	–
8	2	Ø 54 × 4			–
9	3	Ø 53.5 × 3	MILD STEEL		–

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETRES EXCEPT WHERE INCH DIMENSIONS ARE SPECIFIED THUS *.
2. TOLERANCES TO BE NON-ACCUMULATIVE.
3. UNLESS OTHERWISE SPECIFIED, TOLERANCES ON DIMENSIONS SHALL BE AS FOLLOWS:

		UNMACHINED WORK	MACHINED WORK
	≤ 50	±0.5	±0.075
>50	≤ 250	±1.0	±0.15
>250	≤ 500	±1.5	±0.25
>500	≤ 1000	±2.0	±0.5
>1000	≤ 6000	±4.0	±1.5
ANGLES		±0.5°	AS NOTED

4. UNLESS OTHERWISE SPECIFIED, MACHINED SURFACE FINISHES SHALL BE 3.2/ MICRONS OR BETTER (ARITHMETICAL MEAN).
5. BREAK ALL SHARP CORNERS AND EDGES.
6. UNLESS OTHERWISE SPECIFIED, FILLET RADII SHALL BE MIN. 0.2 MAX. 0.7.
7. ALL SIZES GIVEN ARE FINISHED OVERALL. MACHINING AND TRIMMING ALLOWANCES SHALL BE DETERMINED BY FABRICATOR.
8. UNLESS OTHERWISE SPECIFIED, ALL SCREW THREADS SHALL HAVE STANDARD COARSE PITCH AND A CLASS 6g/6H FIT.
9. ALL WELD SYMBOLS ARE IN ACCORDANCE WITH THE CSA STANDARD W47.1.

Sandwell Beak Research Group
Centrifugal Separating Machine

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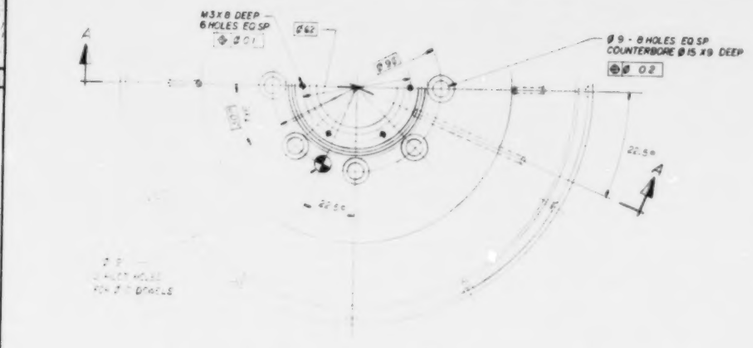
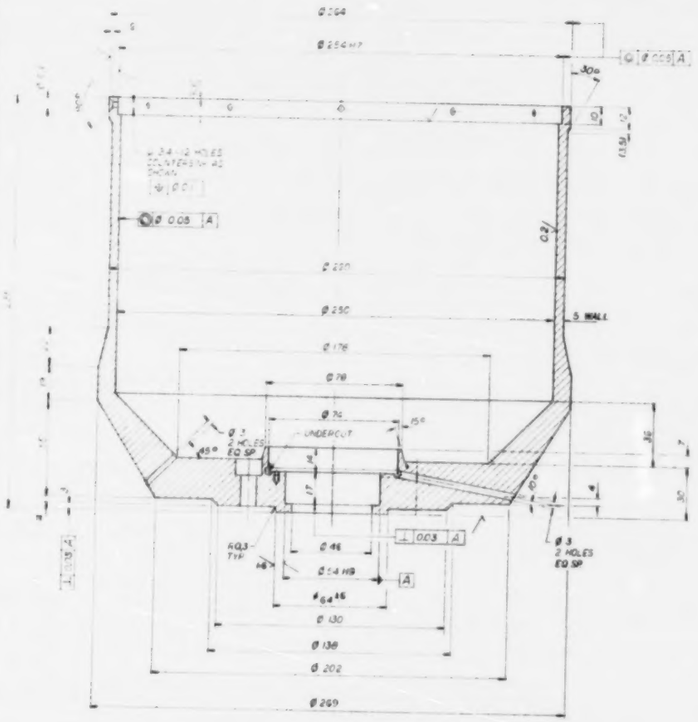
CYLINDER AND SPACER DETAILS

DSMA International Inc.
Engineers and Constructors
Toronto, Canada

SCALE 1:1 & 2:1 | SHEET 1 OF 1 SHEETS | PROJECT 4053 | SECTION | SIZE E | DWG. NO. 4053-106 | ISSUE 1

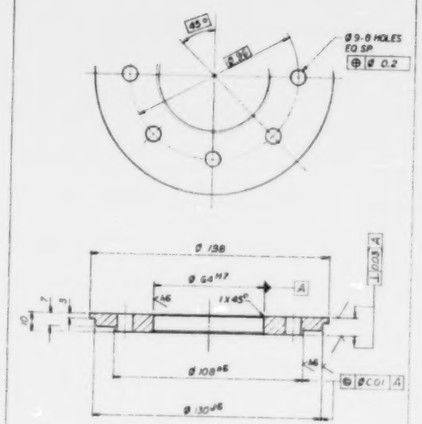




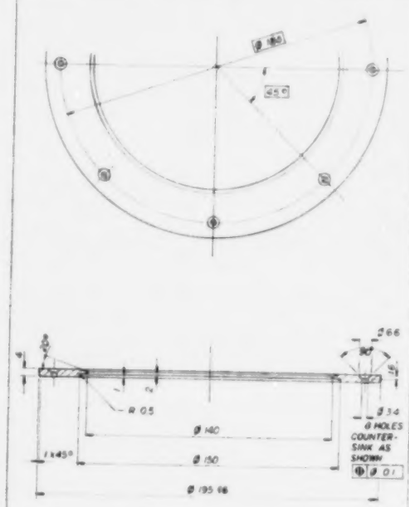
SECTION A - A

① SEPARATOR BOWL 4053-107A ONE REQ'D

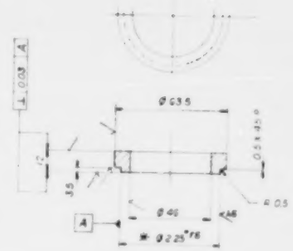
EST. WEIGHT 11.5 Kg



② INSULATOR 4053-107B ONE REQ'D

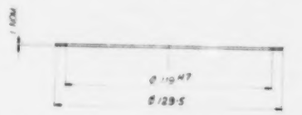


④ HEAT SHIELD 4053-107D ONE REQ'D

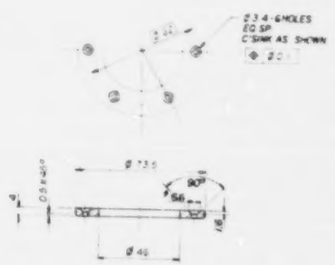


③ SEAL COVER 4053-107C ONE REQ'D

⑤ SHIM 4053-107E ONE REQ'D



⑥ SHIM 4053-107F ONE REQ'D



⑦ COVER 4053-107G ONE REQ'D

DWG. NO.	REFERENCE DRAWS
4053-102	SEPARATOR ASSEMBLY

BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	MATERIAL	NOTE	WT
1	1	Ø 269 x 235			
2	1	Ø 138 x 10 (DUPONT)			
3	1	Ø 63.5 x 12			
4	1	Ø 195 x 4 (DUPONT)			
5	1	Ø 3.5 x 1.35			
6	1	Ø 129.5 x 1			
7	1	Ø 73.5 x 4			

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETRES EXCEPT WHERE INCH DIMENSIONS ARE SPECIFIED THUS "
2. TOLERANCES TO BE NON-ACCUMULATIVE.
3. UNLESS OTHERWISE SPECIFIED, TOLERANCES ON DIMENSIONS SHALL BE AS FOLLOWS:

	UNMACHINED WORK	MACHINED WORK
< 50	±0.5	±0.075
> 50 < 250	±1.0	±0.15
> 250 < 500	±1.5	±0.25
> 500 < 1000	±2.0	±0.5
> 1000 < 6000	±4.0	±1.5
ANGLES	±0.5°	AS NOTED

4. UNLESS OTHERWISE SPECIFIED, MACHINED SURFACE FINISHES SHALL BE 3.2µ" MICRONS OR BETTER (ARITHMETICAL MEAN).
5. BREAK ALL SHARP CORNERS AND EDGES.
6. UNLESS OTHERWISE SPECIFIED, FILLET RADII SHALL BE MIN. 0.2 MAX. 0.5.
7. ALL SIZES GIVEN ARE FINISHED OVERALL. MACHINING AND TRIMMING ALLOWANCES SHALL BE DETERMINED BY FABRICATOR.
8. UNLESS OTHERWISE SPECIFIED, ALL SCREW THREADS SHALL HAVE STANDARD COARSE PITCH AND A CLASS 6g/6H FIT.
9. IF WELDING IS REQUIRED THE WELDS TO BE FULL PENETRATION.

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REVISION	AS DRAWN

SEPARATOR
DETAILS I

Sandwell Beak Research Group
Centrifugal Separating Machine

DSMA International Inc.
Engineers and Constructors
Toronto, Canada

SCALE	SHEET	SIZE	DWG. NO.	REV.
FULL SIZE	1 OF 1	E	4053-107	

PROJECT 4053

E 4053-108

M6 - 11 DEEP 8 HOLES EQ SP

Ø9 - 2 PILOT HOLES

Ø 11 - 8 HOLES EQ SP Ⓜ Ø 0.4

45°

M6 X 8 DEEP 2 HOLES

LOCATION FOR Ø6 DOWEL AT ASSEMBLY

'B'

99

2

TYP (5)

Ø 272

Ø 300 H7

Ø 195 H7

Ø 166 H7

Ø 165 +.027 0

Ø 138

Ø 156

Ø 150

Ø 202

Ø 132

147

Ø 170

Ø 200

2 HOLES

Ø5 THRU ⅛" NPTF 2 HOLES

1 x 45° TYP

2 R

M8 x 10 DEEP 4 HOLES EQ SP (DO NOT BREAK THROUGH INTERIOR WALL)

Ø 0.01 A

'A'

HOUSING 4053-108 A ONE REQ'D

M6 - 8 DEEP 2 HOLES Ⓜ Ø 0.1

10 REF

Ø10 THRU HOLE

VIEW 'B'

7 R

Ø 18

15°

22.5°

Ø5 Ø 9.5 Ø 9.5

* ⅛" NPTF

ITEM 4

ITEM 3

M8 X 19 DEEP 8 HOLES EQ SP Ⓜ Ø 0.2

22½°

Ø 200

Ø 182

73.5

VIEW 'A'

DWG. NO.	REFERENCE DWGS.
4053-102	SEPARATOR ASSEMBLY

BILL OF MATERIAL

ITEM	QTY.	DESCRIPTION	MATERIAL	NOTE	WT
1	1	Ø 202 x 348	304L or 316 TYPE 316		3.9
2	1	Ø 340 x 71	—		1.5
3	9	48 x 5 x 70	—		—
4	2	40 x 28 x 40	—		—
5	1	IRREGULAR SHAPE x 2	—		—
6	2	13 x 2 x 595	—		—

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETRES EXCEPT WHERE NON DIMENSIONS ARE SPECIFIED THUS "
2. TOLERANCES TO BE NON-ACCUMULATIVE.
3. UNLESS OTHERWISE SPECIFIED, TOLERANCES ON DIMENSIONS SHALL BE AS FOLLOWS:

		UNMACHINED WORK	MACHINED WORK
	≤ 50	±0.5	±0.075
> 50	≤ 250	±1.0	±0.15
> 250	≤ 500	±1.5	±0.25
> 500	≤ 1000	±2.0	±0.5
> 1000	≤ 6000	±4.0	±1.5
ANGLES		±0.5°	AS NOTED

4. UNLESS OTHERWISE SPECIFIED, MACHINED SURFACE FINISHES SHALL BE 3.2 MICRONS OR BETTER (ARITHMETICAL MEAN).
5. BREAK ALL SHARP CORNERS AND EDGES.
6. UNLESS OTHERWISE SPECIFIED, FILLET RADII SHALL BE MIN. 0.2 MAX. 0.5
7. ALL SIZES GIVEN ARE FINISHED OVERALL. MACHINING AND TRIMMING ALLOWANCES SHALL BE DETERMINED BY FABRICATOR.
8. UNLESS OTHERWISE SPECIFIED, ALL SCREW THREADS SHALL HAVE STANDARD COARSE PITCH AND A CLASS 6g/6H FIT.
9. ALL WELD SYMBOLS ARE IN ACCORDANCE WITH THE CSA STANDARD W47.1
10. ALL WELDMENTS SHALL BE STRESS RELIEVED BEFORE MACHINING.
11. ALL GUSSETS TO BE CHAMFERED TO CLEAR CORNER WELDS.

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1	BM	AS DRAWN		REVISION

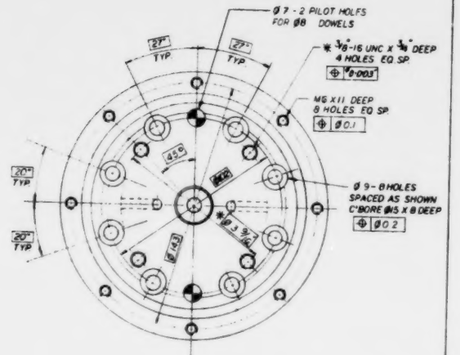
HOUSING DETAIL

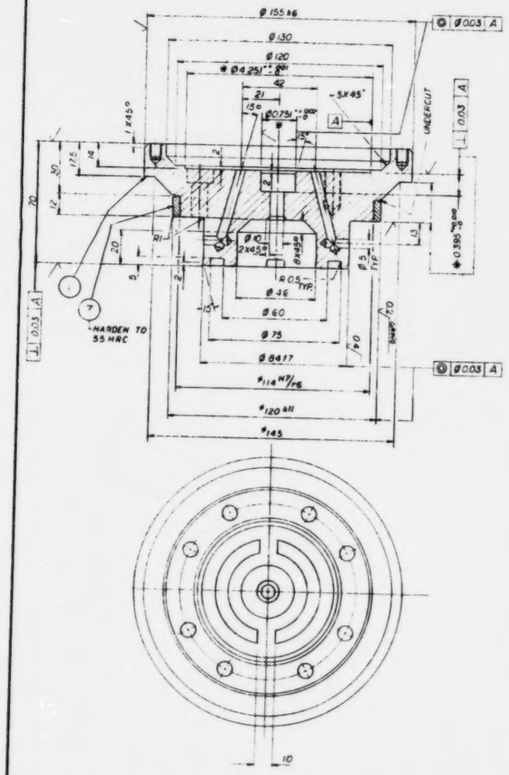
Sandwell Beak Research Group
Centrifugal Separating Machine

DSMA International Inc.
Engineers and Constructors
Toronto, Canada

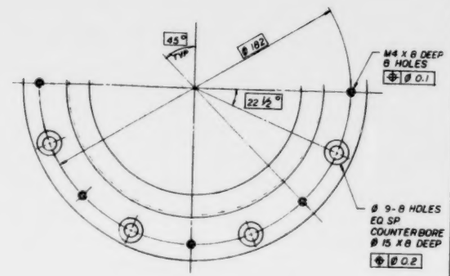
PROJECT	SECTION	SIZE	DWG. NO.	SHEET
4053		E	4053-108	1

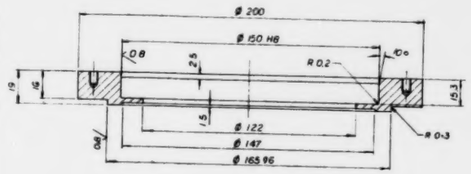
DWG. NO. 4053-109 | E


Ø 7 - 2 PILOT HOLES FOR Ø8 DOWELS
27° TYP
27° TYP
* 3/8-16 UNC x 3/4 DEEP 4 HOLES EQ SP
⌖ Ø.003
M6 x 11 DEEP 8 HOLES EQ SP
⌖ Ø.1
20° TYP
20° TYP
45°
Ø 9 - 8 HOLES SPACED AS SHOWN C'BORE Ø15 X 8 DEEP
⌖ Ø.2

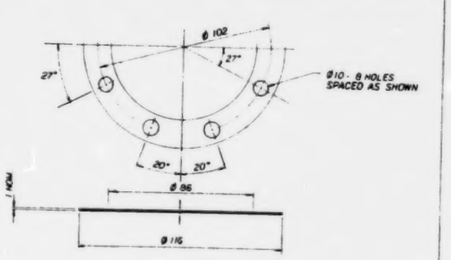


SPROCKET HOUSING 4053-109A ONE REQ'D

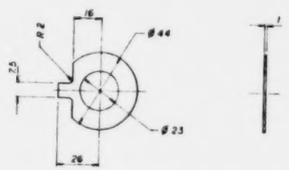




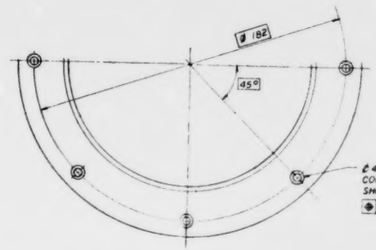
② SEAL HOUSING 4053-109B ONE REQ'D

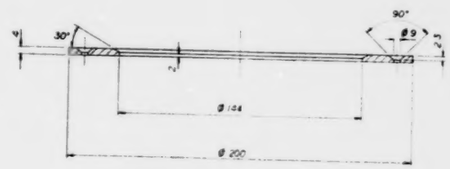


③ SHIM 4053-109D ONE REQ'D

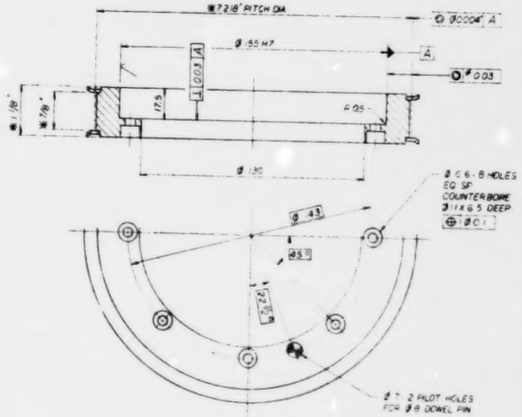


④ TAB WASHER 4053-109E ONE REQ'D





⑤ SEAL RETAINER 4053-109C ONE REQ'D



⑥ SPROCKET 4053-109F ONE REQ'D

DWG. NO.	REFERENCE DWGS.
4053-102	SEPARATOR ASSEMBLY

BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	MATERIAL	NOTE	WT.
1	1	Ø 155 X 70	[illegible]		4
2	1	Ø 200 X 19	[illegible]		2
3	1	Ø 116 X 1	—		—
4	1	44 X 1 X	—		—
5	1	Ø 200 X 4	—		—
6	1	UNIROYAL MADE-TO ORDER SPROCKET FOR 8mm PITCH HTD BELT 72 GROOVES, 20mm WIDTH 4600 RPM	STEEL	9	2
7	1	9120 x 14 x 12	[illegible]		—

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETRES EXCEPT WHERE INCH DIMENSIONS ARE SPECIFIED THUS *
2. TOLERANCES TO BE NON-ACCUMULATIVE.
3. UNLESS OTHERWISE SPECIFIED, TOLERANCES ON DIMENSIONS SHALL BE AS FOLLOWS:

		UNMACHINED WORK	MACHINED WORK
> 50	≤ 50	±0.5	±0.075
> 250	≤ 250	±1.0	±0.15
> 500	≤ 500	±1.5	±0.25
> 1000	≤ 1000	±2.0	±0.5
> 1000	≤ 6000	±4.0	±1.5
ANGLES		±0.5°	AS NOTED

4. UNLESS OTHERWISE SPECIFIED, MACHINED SURFACE FINISHES SHALL BE 3.2/ MICRONS OR BETTER (ARITHMETICAL MEAN).
5. BREAK ALL SHARP CORNERS AND EDGES.
6. UNLESS OTHERWISE SPECIFIED, FILLET RADII SHALL BE MIN. 0.2 MAX. 0.7
7. ALL SIZES GIVEN ARE FINISHED OVERALL, MACHINING AND TRIMMING ALLOWANCES SHALL BE DETERMINED BY FABRICATOR.
8. UNLESS OTHERWISE SPECIFIED, ALL SCREW THREADS SHALL HAVE STANDARD COARSE PITCH AND A CLASS 6g/6H FIT.
9. SUPPLIER: TORONTO GEAR WORKS
112 SINNLTT. RD
SCARBORO ONT MIL 4W8

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1 REVISIONS

1	SW	AS DRAWN	

PROJECTION

P DUGGAN

SEPARATOR DETAILS II

Sandwell Beak Research Group
Centrifugal Separating Machine

DSMA International Inc.
Engineers and Constructors
Toronto, Canada

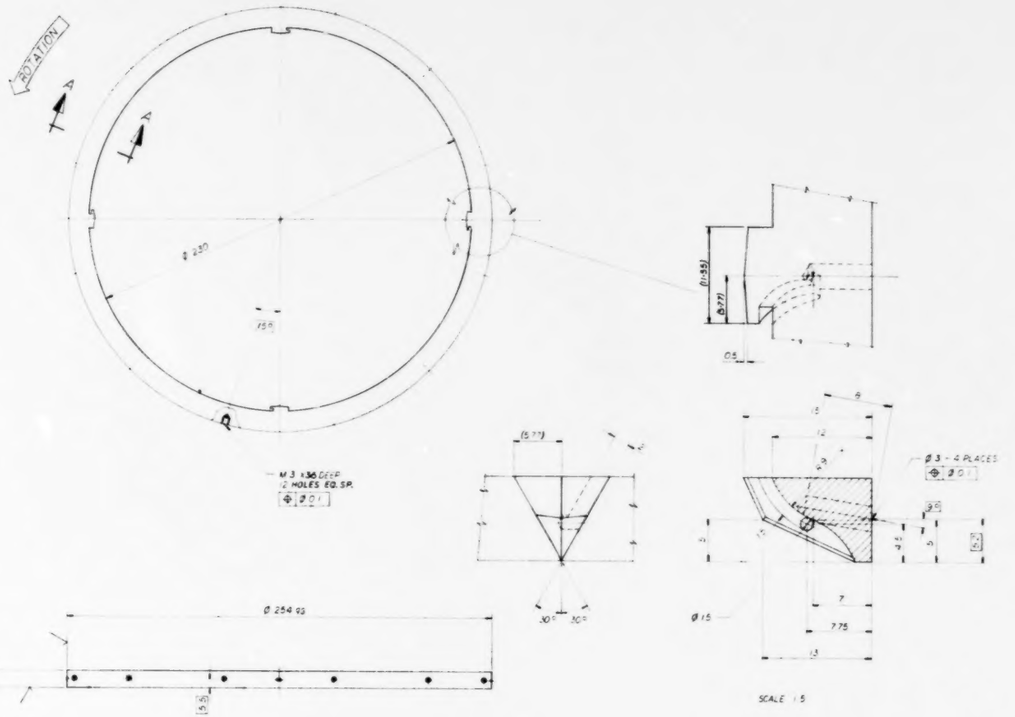
SCALE FULL SIZE | PROJECT 4053 | SECTION | SIZE E | DWG. NO. 4053-109 | SHEET 1 OF 1 SHEETS | ISSUE 1

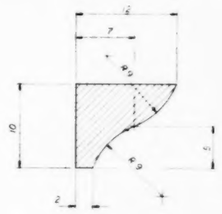
4053-110

DWG. NO.	REFERENCE DWGS.
4053-102	SEPARATOR ASSEMBLY

BILL OF MATERIAL

ITEM	QTY.	DESCRIPTION	MATERIAL	NOTE	WT.
1	1	Ø 254 x 10	SPL [3] [4]		–





SECTION A-A
SCALE 5:1

① LIQUID TAKE OFF PORT DETAIL 4053-110A ONE REQD

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETRES EXCEPT WHERE INCH DIMENSIONS ARE SPECIFIED THUS *
2. TOLERANCES TO BE NON-ACCUMULATIVE.
3. UNLESS OTHERWISE SPECIFIED, TOLERANCES ON DIMENSIONS SHALL BE AS FOLLOWS:

		UNMACHINED WORK	MACHINED WORK
	≤ 50	±0.5	±0.075
> 50	≤ 250	±1.0	±0.15
> 250	≤ 500	±1.5	±0.25
> 500	≤ 1000	±2.0	±0.5
> 1000	≤ 6000	±4.0	±1.5
ANGLES		±0.5°	AS NOTED

4. UNLESS OTHERWISE SPECIFIED, MACHINED SURFACE FINISHES SHALL BE 3.2/ MICRONS OR BETTER (ARITHMETICAL MEAN)*
5. BREAK ALL SHARP CORNERS AND EDGES.
6. UNLESS OTHERWISE SPECIFIED, FILLET RADII SHALL BE MIN. 0.2 MAX. 0.5
7. ALL SIZES GIVEN ARE FINISHED OVERALL, MACHINING AND TRIMMING ALLOWANCES SHALL BE DETERMINED BY FABRICATOR.
8. UNLESS OTHERWISE SPECIFIED, ALL SCREW THREADS SHALL HAVE STANDARD COARSE PITCH AND A CLASS 6g/6H FIT.

Sandwell Beak Research Group
Centrifugal Separating Machine

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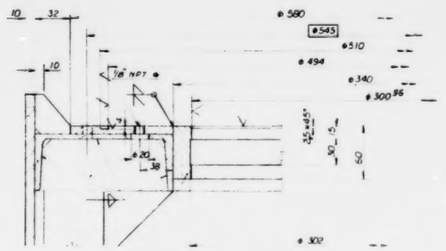
1	SW	AS DRAWN	REVISION

LIQUID TAKE OFF PORT DETAIL

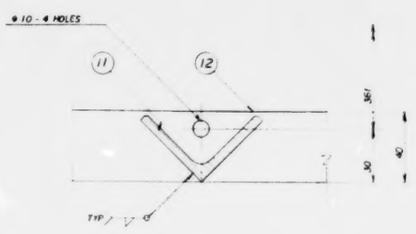
DSMA International Inc.
Engineers and Constructors
Toronto, Canada

PROJECT	SECTION	SIZE	DWG. NO.	ISSUE
4053		E	4053-110	1

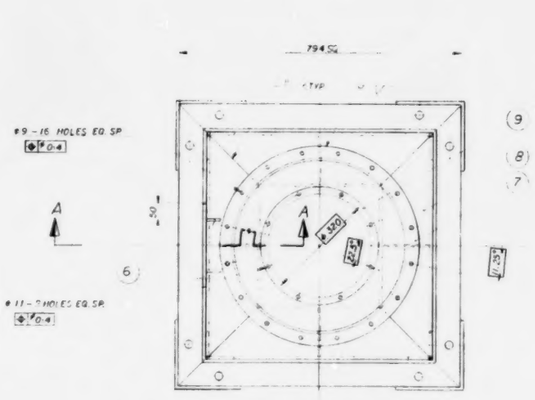
E 4053-111

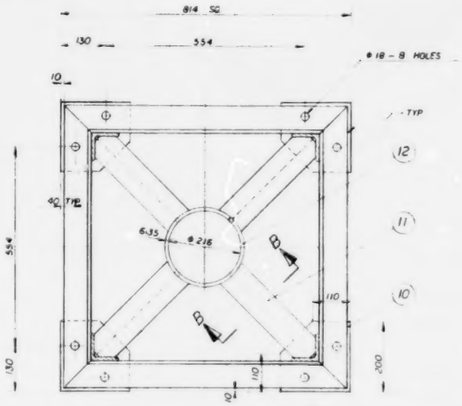


SECTION A-A
SCALE 1:2

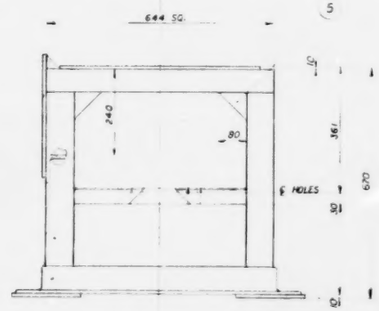


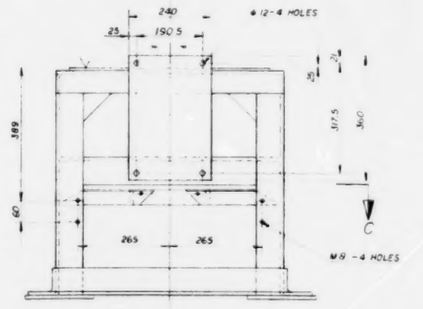
SECTION B-B
SCALE 1:1





SECTION C-C





VIEW D

SUPPORT FRAME 4053-111 A ONE REQ'D
EST. WEIGHT 152 Kg

16

BELT COVER 4053-111 B ONE REQ'D
SCALE 1:2
EST. WEIGHT 5 Kg

SHIM 4053-111 C 2 REQ'D
SCALE 1:2

18 SHIM 4053-111 D ONE REQ'D
SCALE NONE

DWG. NO.	REFERENCE DWGS.
4053 - 100	CENTRIFUGAL SEPARATOR GEN. ASS'Y

BILL OF MATERIAL

ITEM	QTY.	DESCRIPTION	MATERIAL	NOTE	WT.
1	4	L 75 X 75 X 10 X 794	ASTM A 36		33
2	4	L ——— X 575			25
3	1	L ——— X 624			7
4	1	240 X 10 X 360			7
5	9	80 X 10 X 80			2
6	2	32 X 5 X 56			-
7	1	Ø560 X Ø340 X 10			14
8	4	C 150 X 19 X 644			38
9	1	Ø 340 X Ø300 X 160			9
10	4	200 X 10 X 200			11
11	4	L 55 X 55 X 5 X 326			5
12	1	9 5/8 X 1/4 WALL X 40 LG.			1
13	4	40 X 3 X 134			-
14	1	97 X 3 X 902			2
15	1	IRREGULAR SHAPE X 3			2
16	2	100 X 6 X 130			1
17	2	80 X 13 NOM X 220			2
18	1	Ø338 X Ø306 X 1 NOM			-

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETRES EXCEPT WHERE INCH DIMENSIONS ARE SPECIFIED THUS ".
2. TOLERANCES TO BE NON-ACCUMULATIVE.
3. UNLESS OTHERWISE SPECIFIED, TOLERANCES ON DIMENSIONS SHALL BE AS FOLLOWS:

		UNMACHINED WORK	MACHINED WORK
	≤ 50	±0.5	±0.075
> 50	≤ 250	±1.0	±0.15
> 250	≤ 500	±1.5	±0.25
> 500	≤ 1000	±2.0	±0.5
> 1000	≤ 6000	±4.0	±1.5
ANGLES		±0.5°	AS NOTED

4. UNLESS OTHERWISE SPECIFIED, MACHINED SURFACE FINISHES SHALL BE 3.2 MICRONS OR BETTER (ARITHMETICAL MEAN).
5. BREAK ALL SHARP CORNERS AND EDGES.
6. UNLESS OTHERWISE SPECIFIED, FILLET RADII SHALL BE MIN. 0.3 MAX. 3.
7. ALL SIZES GIVEN ARE FINISHED OVERALL. MACHINING AND TRIMMING ALLOWANCES SHALL BE DETERMINED BY FABRICATOR.
8. UNLESS OTHERWISE SPECIFIED, ALL SCREW THREADS SHALL HAVE STANDARD COARSE PITCH AND A CLASS 6g/6H FIT.
9. LOCTITE SEALANT GRADE AV SHALL BE APPLIED TO FASTENER THREADS WHERE MECHANICAL LOCKING IS IMPRACTICABLE.
10. ALL WELD SYMBOLS ARE IN ACCORDANCE WITH THE CSA STANDARD W47.1.
11. ALL WELDMENTS SHALL BE STRESS RELIEVED BEFORE MACHINING.
12. ALL GUSSETS TO BE CHAMFERED TO CLEAR CORNER WELDS.

Sandwell Beak Research Group
Centrifugal Separating Machine

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REVISION	BY	DATE
1	RS	DRAWN

PROJECTION: THIRD ANGLE
ENGINEERED
DRAWN RS
CHECKED
APPROVED
P. HOGAN

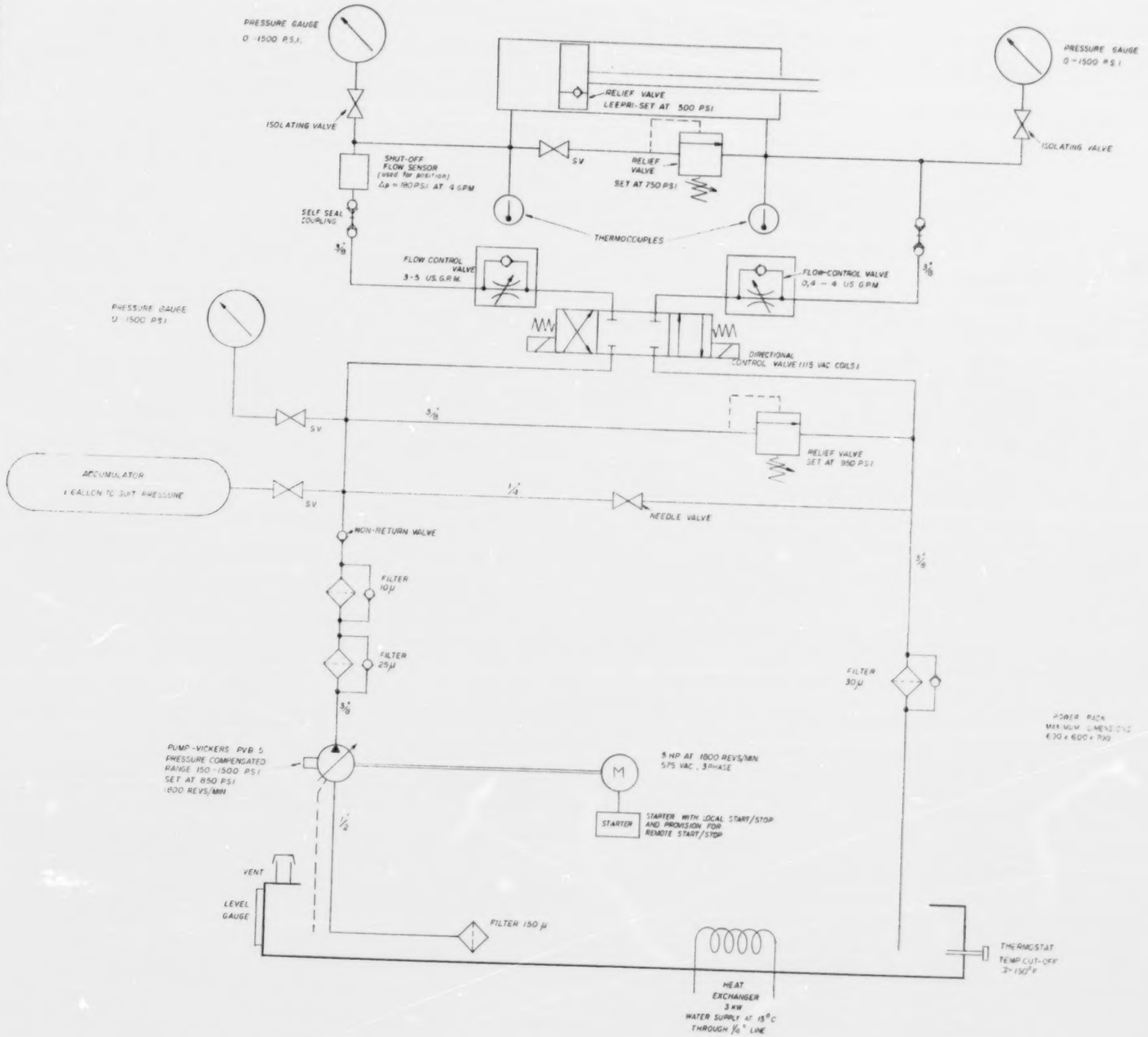
CENTRIFUGAL SUPPORT FRAME

DSMA International Inc.
Engineers and Constructors
Toronto, Canada

SCALE 1/5 & AS NOTED | SHEET 1 OF 1 SHEETS

PROJECT	SECTION	SUB	DWG. NO.	ISSUE
4053		E	4053 - 111	1

E 4053-112


PRESSURE GAUGE
0 - 1500 P.S.I.
ISOLATING VALVE
SHUT-OFF FLOW SENSOR (valve for indicator) Δp = 190 P.S.I. AT 4 G.P.M
SELF SEAL COUPLING
3/8"
RELIEF VALVE LEE PRI-SET AT 500 PSI
S.V.
RELIEF VALVE SET AT 750 PSI
THERMOCOUPLES
PRESSURE GAUGE 0 - 1500 P.S.I.
ISOLATING VALVE
FLOW CONTROL VALVE 3 - 5 U.S. G.P.M.
FLOW CONTROL VALVE 0,4 - 4 U.S. G.P.M.
DIRECTIONAL CONTROL VALVE 115 VAC COILS
PRESSURE GAUGE 0 - 1500 P.S.I.
S.V.
3/8"
RELIEF VALVE SET AT 950 P.S.I.
ACCUMULATOR 1 GALLON TO SUIT PRESSURE
S.V.
1/4"
NEEDLE VALVE
NON-RETURN VALVE
FILTER 10μ
FILTER 25μ
3/8"
FILTER 30μ
3/8"
PUMP - VICKERS PVB 5 PRESSURE COMPENSATED RANGE 150 - 1500 P.S.I. SET AT 850 P.S.I. 1800 REVS/MIN
M
5 H.P. AT 1800 REVS/MIN 575 VAC, 3 PHASE
STARTER
STARTER WITH LOCAL START/STOP AND PROVISION FOR REMOTE START/STOP
1/2"
VENT
LEVEL GAUGE
FILTER 150 μ
HEAT EXCHANGER 3 KW WATER SUPPLY AT 18°C THROUGH 1/4" LINE
THERMOSTAT TEMP CUT-OFF 2" 150°F
POWER PACK MAXIMUM DIMENSIONS 630 x 600 x 710

ITEM NO.	REFERENCE DRWG.

BILL OF MATERIAL

ITEM QTY.	DESCRIPTION	MATERIAL	NOTE	QTY.

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REVISION						
1	MAH	AS DRAWN				

DESIGNED A.C.L.
DRAWN M.A.H.
CHECKED
APPROVED

P. LOGAN

HYDRAULIC SCHEMATIC

Sandwell Beak Research Group
Centrifugal Separating Machine

DSMA International Inc.
Engineers and Constructors
Toronto, Canada

SCALE NONE | SHEET 1 OF 1 | CONTD

PROJECT 4053 | SECTION | SIZE E | DWG. NO. 4053-112 | ISSUE 1

APPENDIX A

MINUTES OF MEETINGS

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: DSMA International Inc.
10 Park Lawn Road
Toronto, Ontario
M8Y 3H8

DATE: July 16, 1984

PRESENT: P. Groeneweg - SBRG
V. Silaghi - DSMA

DISTRIBUTION: S.L. Hodd - SBRG
P. Groeneweg - SBRG
C. Balkwill - DSMA
V. Silaghi - DSMA
P. Duggan - DSMA
File 4053/B1

DISCUSSIONS	ACTION
1. HYDRAULIC CYLINDER	
In order to incorporate the smaller 120 mm bore diameter bearing it was agreed that the piston diameter will be maintained at 3¼".	
The piston rod diameter will be reduced from 2" to 1 3/4" diameter.	DSMA
2. BEARINGS	
Due to closure of the Kaydon facility for holidays, the use of Kaydon bearings for the separator bowl support could not be fully investigated.	
The TRW bearings proposed (120 Ø x 165 x 22) MCR 1924-5, class 3 are limited to 4200 RPM rotational speed with grease lubrication and TRW suggests oil lubrication for higher speeds.. Another possibility is the use of class 7 bearings but these have a 22 week delivery. DSMA agreed to further investigate the use of Kaydon angular contact bearings with grease lubrication if possible.	DSMA

DISCUSSIONS	ACTION
3. THERMAL EFFECTS It was agreed that the proposed thermal insulation plastic insert between piston rod and scraper will be eliminated. DSMA will investigate the use of a suitable insulation material between the separator bowl and hydraulic cylinder in order to create an effective thermal barrier. The 2" thick insulation will be extended to the cylinder walls to maintain a tank ambient temperature of 200°C around the liquid drain area.	DSMA
4. CONTAINMENT VESSEL The tank will be provided with a removable door to gain access to internal components. The solvent tank will include a lower drain port with the bottom surface inclined towards the drain. The tank cover will include 3 - 4 transparent observation ports. Next meeting to be held July 18 at 1:30 p.m.	

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: DSMA International Inc.
10 Park Lawn Road
Toronto, Ontario
M8Y 3H8

DATE: July 18, 1984

PRESENT: P. Groeneweg - SBRG
V. Silaghi - DSMA

DISTRIBUTION: S.L. Hodd - SBRG
P. Groeneweg - SBRG
C. Balkwill - DSMA
V. Silaghi - DSMA
P. Duggan - DSMA
File 4053/B1

DISCUSSIONS	ACTION
1. BEARINGS Kaydon bearings proposed for the separator bowl support are not available from stock and earliest delivery is estimated in September. This is unacceptable to SBRG and it was agreed that the TRW bearing will be incorporated with a provision to switch from grease to oil lubrication if required. The bearing housing will include two water cooled grooves to maintain an ambient working temperature at the bearings.	
2. THERMAL EFFECTS Glass reinforced nylon proposed for use as a thermal insulator is not available in sizes large enough for installation in the assembly. Vespel SP-21 or SP-22 by Dupont is proposed by DSMA as this can operate up to 500° and has an acceptable compressive strength. The time/temperature relationship for this material will be further investigated.	DSMA

DISCUSSIONS	ACTION

3. CONTAINMENT VESSEL

It was agreed that the solvent tank will be split and a flange bolted to a support tank so that alignment between the bowl and liquid collection conduit can be easily achieved.

The liquid collection conduit will have a machined bore to ensure concentricity with the separator bowl.

The shape of the liquid collection conduit will be modified using a radiused wall to prevent splash back and to include 0.5" dia. ports for rapid drainage of the liquid. The bottom wall is to be inclined and provided with a drain plug at the lowest level.

The tank cover will incorporate a 0.5" I. Dia. slurry feed line, 4 circular observation ports and the solids deflector plates will be modified to improve visibility around the bowl insert.

Next meeting to be held July 23 at 1:30 p.m.

MINUTES OF MEETING

PROJECT: DSMA Project 4[illegible]3
Centrifugal Separating Machine

PLACE: DSMA International Inc.
10 Park Lawn Road
Toronto, Ontario
M8Y 3H8

DATE: July 23, 1984

PRESENT: P. Groeneweg - SBRG
V. Silaghi - DSMA
P. Duggan - DSMA

DISTRIBUTION: S.L. Hodd - SBRG
P. Groeneweg - SBRG
C. Balkwill - DSMA
V. Silaghi - DSMA
P. Duggan - DSMA

DISCUSSIONS	ACTION
1. EQUIPMENT FABRICATION Several potential machine shops including Hörn Industries, Leavens Bros., Rexdale Tooling and Man-Des Industries have been visited by SBRG personnel. Suitable fabricators for the containment vessel will be visited this week and a list prepared of those contractors selected to receive bid packages. 2. SI UNITS Several contractors have expressed a preference for detail drawings in Imperial units rather than SI units, and prefer not to work with drawings containing mixed units. DSMA pointed out that drawings with mixed units are inevitable since bearings, and several seals are only available in metric sizes while hydraulic piston seals and rod packing seals are only available in Imperial sizes.	

DISCUSSIONS	ACTION
It was agreed that detail drawings will be completed in S.I. units as far as possible with a minimum number of Imperial size components included.	DSMA
3. LIQUID TAKE-OFF PORTS Detail design of the liquid take-off ports was discussed and it was agreed that the port assemblies should be installed as a separate insert based on a contoured section cut from a separate machined ring. The drilled port will be sloped to the outside bowl surface in order to lower the level of the surrounding liquid collection conduit and prevent restriction of the exiting centrifuged solids.	
4. TIEBARS It was agreed that provision will be made for support of the lower end of the separator sub assembly by the use of tiebars. These will be included in the design but only used if necessary.	DSMA
5. BEARINGS TRW have confirmed that the separator bowl support bearings should be capable of operation with grease lubrication, but provision will still be made for the inclusion of oil lubrication if necessary. DSMA have calculated that these bearings could support up to 15% of out of balance load and SBRG confirmed that these loads should be well within this limit due to the homogenous nature of the slurry feed.	
6. SCRAPER PISTON The rear face of the scraper piston will be flared to prevent centrifuged solids being carried back down the separator bowl.	DSMA
A suitable seal to prevent the contamination of the piston rod packing has not yet been selected. It was agreed that this seal may be eliminated if a suitable component cannot be found.	

DISCUSSIONS	ACTION
7. CONTAINMENT VESSEL SBRG expressed concern regarding the lower tank interface and the possibility of distortion. Several other schemes were discussed but it was agreed that installation of the separator sub assembly from above is highly desirable, and the design of the interface flange will be reviewed in more detail by DSMA.	DSMA
8. SCHEDULE DSMA expect to complete detail design drawings of the separator sub assembly by July 27 and checking will commence July 30. Preliminary Drawings may be used for discussions with contractors prior to the completion of the checking procedure. Detail drawings of the Containment Vessel Assembly will commence July 30. Next meeting will be held July 26 at 1:30 p.m.	

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: DSMA International Inc.
10 Park Lawn Road
Toronto, Ontario
M8Y 3H8

DATE: July 27, 1984

PRESENT: P. Groeneweg - SBRG
V. Silaghi - DSMA
P. Duggan - DSMA

DISTRIBUTION: S.L. Hodd - SBRG
P. Groeneweg - SBRG
C. Balkwill - DSMA
V. Silaghi - DSMA
P. Duggan - DSMA

DISCUSSIONS	ACTION
1. HARDWARE LIST The list of hardware to be purchased for the Centrifugal Separator Sub assembly was reviewed and several items clarified. The cost of Vespel to be used as thermal insulation is high and DSMA agreed to seek alternatives.	DSMA
2. HEAT TRANSFER It was agreed that in order to improve heat removal rates around theupper bearing assembly it would be desirable to maintain a constant flow of oil through the hydraulic cylinder. This can be achieved by installing a pressure relief valve in the head of the piston which allows flow only from the upper to the lower face of the piston. The valve may be selected on the basis of continuous flow when the scraper is not activated or with a cracking pressure slightly above the operational back pressure required on the piston. DSMA agreed to modify the piston design in order to incorporate a suitable valve.	DSMA

DISCUSSIONS	ACTION
SBRG will determine the volumetric flow rate required to maintain an acceptable temperature at the upper bearing.	SBRG
3. LIQUID TAKE-OFF PORTS DSMA agreed to modify the port design in order to maintain a 5 mm depth above the bowl surface and a 5 mm overflow depth at the upper edge of the bowl. The design will be further modified to incorporate a direct radial port to the collector conduits in place of the existing tapered port.	DSMA
4. DETAIL DRAWINGS Detail drawings for the Separator Sub assembly are 80% complete and preliminary copies were handed over to SBRG for discussions with potential fabricators. Checking of detail drawings will commence July 30. Next meeting to be held July 30 at 1:30 p.m.	

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: DSMA International Inc.
10 Park Lawn Road
Toronto, Ontario
M8Y 3H8

DATE: July 30, 1984

PRESENT: P. Groeneweg - SBRG
P. Duggan - DSMA

DISTRIBUTION: S.L. Hodd - SBRG
P. Groeneweg - SBRG
C. Balkwill - DSMA
V. Silaghi - DSMA
P. Duggan - DSMA

DISCUSSIONS	ACTION
1. LEE PLUGS SBRG prefer to purchase the necessary Lee Plugs and Leepri valve for the Separator Sub assembly from a Canadian agent to avoid hardware importation problems. DSMA agreed to investigate the availability of a Canadian agent.	DSMA
2. HYDRAULIC PISTON DSMA have revised the design of the hydraulic piston to incorporate the Leepri pressure relief valve which will be used to maintain a constant flow of oil through the hydraulic cylinder. The piston has been extended in length and a recess included in the cylinder end cap. The piston locknut spring washer has been exchanged for a more positive lock washer.	

DISCUSSIONS	ACTION
3. VALVE SIZING It was agreed that the pressure relief valve will be selected on the basis of 1/3 of the flow calculated as a requirement through the entrance ports in order to move the scraper piston from top to bottom of stroke in 3 sec.	DSMA
4. PISTON ROD SEALS DSMA suggested that a preferred approach to the scraper ring seals would be to install the rings in the cylinder from above with an upper flange to lock these rings in place. The rings would be centred around the piston rod prior to clamping. SBRG expressed concern that the present design will allow hydrocarbon fluids to be trapped above the upper sealing ring and the rings should be elevated to ensure that deposited fluids will drain away effectively. DSMA agreed to investigate the possibility of incorporating these piston rings in a sub assembly which will permit material changes if bronze rings prove ineffective in use.	DSMA
5. HEAT TRANSFER SBRG have calculated that a relief valve bleed rate of 1/3 x max. cylinder flow on a downward stroke should be adequate to maintain reasonable temperatures at the upper support bearing. Concern was expressed, however, regarding the possibility of process vapours condensing on the piston rod while the scraper is in the upper position. This condensed liquid could pass by the bronze scraper rings and attack the packing seals and dilute the hydraulic oil in the cylinder. DSMA agreed to continue the search for a flexible metal seal which could reliably remove condensed liquid from the surface of the piston rod and provide a means of draining this condensed liquid.	DSMA
6. LIQUID EXIT PORTS SBRG pointed out that the DSMA proposed design for the liquid exit ports is not acceptable and modifications are required. The present slot design for liquid drainage would permit blockage by solids. The bowl surface inside the slot should not be stepped but sloped as closely as possible to the upper bowl contour. DSMA will modify the exit port design to incorporate these requirements.	DSMA

DISCUSSIONS	ACTION
7. SOLVENT MIXER SBRG agreed to supply urgently details of the proposed mixer and drive unit to be inserted in the solvent bowl.	SBRG
8. CONTROLS REVIEW Next meeting will be held at SBRG offices on July 31 at 2 p.m. to discuss requirements for the hydraulic control system and necessary interlocks.	

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: Sandwell Beak Research Group
6870 Goreway Drive
Mississauga, Ontario
L4V 1L9

DATE: August 1, 1984

PRESENT: P. Groeneweg - SBRG
L. Howarth - SBRG
C. Balkwill - DSMA
P. Duggan - DSMA

DISTRIBUTION: S.L. Hodd - SBRG
P. Groeneweg - SBRG
L. Howarth - SBRG
C. Balkwill - DSMA
P. Duggan - DSMA
V. Silaghi - DSMA
File 4053/B1

DISCUSSIONS	ACTION
1. GENERAL The purpose of the meeting was to review potential control techniques for the centrifugal separator assembly and establish hydraulic system hardware requirements. 2. SCRAPER POSITION SENSOR Continuous Sensing of the scraper piston position within the separator bowl is difficult to achieve using conventional techniques. The use of linear transducers within the separator bowl or hydraulic cylinder is ruled out by the high rotational speed of the assembly. The use of an ultrasonic sensor to be mounted in the lid of the containment vessel to determine scraper position has been investigated but the absorption and diffraction effects of the centrifuged material make this an impractical solution.	

DISCUSSIONS	ACTION
A sensor which can be mounted in the end cap of a hydraulic cylinder and detect piston position is available but the necessary location of the hydraulic rotary joint at the lower end of the cylinder makes access for this sensor very difficult and would require modifications to the design of the rotary joint. It was agreed that a better solution would be to monitor the flow of hydraulic oil to and from the rotating cylinder with a sensitive flow meter designed for this purpose. DSMA agreed to investigate the availability of such a device with the appropriate control hardware required to supply feedback signals to the control system.	DSMA
3. CONTROL VALVES It was agreed that the absence of a positive feedback position sensor and the requirement for a continuous oil bleed through the hydraulic piston do not suit the use of a hydraulic servovalve for control of the scraper piston. The use of a directional flow control valve is more appropriate and in-line flow control valves can be adjusted to set input/output flow requirements. The directional valve should be 3 position with the centre position blocking oil to inlet and outlet of the cylinder.	
4. POWER PACK The hydraulic power pack will be sized for one centrifugal separator assembly but will incorporate excess pressure and flow capability. Minimum flow requirement is based upon completing a 150 mm piston stroke in 3 seconds. The lower piston position will be regarded as "home" and dwell time at this position will be variable. There is no process requirement for the scraper piston to dwell at the top of the separator bowl. Manual override capability shall be included, but no emergency shutdown as this can be handled elsewhere in the system.	

DISCUSSIONS	ACTION
Control shall be by a two position STOP/START switch with UP/DOWN manual override in the STOP position.	
DSMA to review hydraulic control system requirements and produce of schematic of the proposed system.	DSMA
5. BOWL DRIVE SYSTEM	
Final selection of a separator drive motor has not been made.	
Requirements are to accelerate the mechanical inertia, accelerate incoming slurry feed and overcome rotational skin friction.	
DSMA will calculate final mechanical inertia and estimate effects of skin friction.	DSMA
SBRG will confirm slurry feed requirements and estimate effects of rapid introduction of slurry feed. Slurry feed is to be stopped during the scraper 'up' cycle and restarted during 'down' cycle.	SBRG
Basis of motor sizing to be agreed at the next design review meeting.	
Next meeting to be held at 1:30 p.m. on August 7.	

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: DSMA International Inc.
10 Park Lawn Road
Toronto, Ontario
M8Y 3H8

DATE: August 8, 1984

PRESENT: P. Groeneweg - SBRG
P. Duggan - DSMA

DISTRIBUTION: S.L. Hodd - SBRG
P. Groeneweg - SBRG
C. Balkwill - DSMA
V. Silaghi - DSMA
P. Duggan - DSMA

DISCUSSIONS	ACTION
1. MATERIALS Proposed material for the separator piston rod is 17-4 PH steel with all other metallic components fabricated from 316 stainless steel.	
2. VESPEL Hardware ordering list calls up Vespel SP-21 as material for the thermal insulation barrier. Specifications suggest that Vespel SP-1 may have preferred physical properties. DSMA to investigate.	DSMA
3. WELDING DSMA confirmed that fabrication of the separator bowl using welding techniques is acceptable so long as welded joints are full strength and 100% penetration. Any suggested modifications to the design must be submitted to DSMA for approval.	
4. BALANCING Balancing of the rotating mechanical assembly will be performed at a speed of 5000 RPM. Locations for removal or addition of material are to be selected in conjunction with the fabricator as the need arises.	

DISCUSSIONS	ACTION
5. MIXER Details of an appropriate mixer to stir contents of the solvent tank are not available. It was agreed that a 1" diameter conduit with a standard size pipe flange would be adequate for support of the mixer. The mixer will be installed with its turbine approximately 0.5 in from the base of the solvent trough downstream of the solvent inlet pipe.	
6. SCRAPER RING It was agreed that in order to examine the effects of abrasion on the scraper piston ring, a tungsten carbide coating will not be included on the initial assembly.	
7. LIQUID EXIT PORTS DSMA confirmed that four liquid exit ports of 3 mm diameter have been included at the upper edge of the separator bowl.	
8. MATERIAL CONTACTS DSMA agreed to investigate possible company contacts which could assist in the rapid procurement of raw materials required for the mechanical assembly.	DSMA
9. CONTAINMENT VESSEL Detail drawings of the containment vessel are underway. Preliminary copies will be supplied to SBRG August 9 for discussions with potential fabricators.	DSMA
10. HYDRAULIC FLUID MEASUREMENT DSMA supplied details of a sensitive fluid metering device by the Stauff Corporation which may be used to measure velocity and position of the scraper piston. DSMA have requested more details from the manufacturer.	
11. DRIVE MOTOR Power requirements for the separator drive motor are less than 4 HP for acceleration of the mechanical inertia in 30 seconds. Since the frame size is constant up to 7½ HP it was agreed that a 7½ HP motor will be selected and DSMA will supply a short specification for the motor and drive system.	DSMA

DISCUSSIONS	ACTION
12. HYDRAULIC SCHEMATIC A preliminary schematic of a possible hydraulic control system was supplied to SBRG for review. DSMA will continue to develop this system and finalize component specifications and line sizes.	DSMA

P.Duggan
:am

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: DSMA International Inc.
10 Park Lawn Road
Toronto, Ontario
M8Y 3H8

DATE: August 9, 1984

PRESENT: P. Groeneweg - SBRG
P. Duggan - DSMA

DISTRIBUTION: S.L. Hodd - SBRG
P. Groeneweg - SBRG
C. Balkwill - DSMA
V. Silaghi - DSMA
P. Duggan - DSMA
File 4053/B1

DISCUSSIONS	ACTION
1. SPROCKET HOUSING Anderson Metals, who are quoting on the Separator Sub Assembly, have rightly pointed out that the 316 stainless steel sprocket housing cannot be hardened to 55 RC as requested. This hardness is required locally on the lip seal wear surface. DSMA suggested that 440C may be a suitable alternative, heat treated to an overall 55RC, if stainless material is required to withstand the corrosive effects of process materials in the hydraulic cylinder. SBRG will review this possibility with the equipment bidders.	SBRG
2. BELT DRIVE DSMA confirmed that the anticipated life of the separator toothed drive belt would be 3500 hours for a 20 mm wide belt and 5000 hours for a 30 mm belt. The 20 mm belt is capable of handling up to 10 HP. The standard belt may, however, require sanding on its rear face after assembly to remove high spots and reduce	

DISCUSSIONS	ACTION
out of balance effects. Ground belts can be supplied by the manufacturer, Uniroyal, but delivery is 12 - 14 weeks which would be unacceptable.	
3. POWER REQUIREMENTS SBRG confirmed that power required to accelerate incoming slurry in worse case is less than 1 HP. Excess power capacity is to be used for rapid acceleration and deceleration of the mechanical assembly.	
4. PISTON SLIPPAGE SBRG expressed concern about the potential rotational slip of the piston in the hydraulic cylinder during rapid accelerations of the equipment. DSMA suggested that frictional torques provided by the seals should be adequate to prevent slip. It was agreed that no preventative action will be taken at this time and potential relative movements will be observed during equipment start up.	
5. BOLTING MATERIALS DSMA requested information of material requirements for bolts within the separator bowl environment. SBRG suggested that these should be stainless if possible and DSMA agreed to investigate the availability of corrosion resistant or suitably plated bolts.	DSMA
6. CONTAINMENT VESSEL Detail drawings of the containment vessel were reviewed and it was agreed that the drawings in their present incomplete condition cannot be used for bidding purposes. A further review of these drawings will take place on August 10 along with a review of bids for the separator assembly.	

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: Sandwell Beak Research Group
6870 Goreway Drive
Mississauga, Ontario
L4V 1L9

DATE: August 24, 1984

PRESENT: L. Howarth - SBRG
P. Groeneweg - SBRG (Part Time)
C. Balkwill - DSMA

DISTRIBUTION: S.L. Hodd - SBRG
P. Groeneweg - SBRG
C. Balkwill - DSMA
V. Silaghi - DSMA
P. Duggan - DSMA
File 4053/B1

DISCUSSIONS	ACTION
1. GENERAL The purpose of the meeting was to review the progress to date of the scraper control system. 2. POSITION SENSOR The Stauff flow sensor was reviewed, and while it was recognized that it is quite an expensive solution to the position sensing problem (at approx. US $2500), it was agreed to use it, since past searches for alternate solutions have failed to come up with any suitable alternative. Futher consideration was given to attempt to use spare capacity in the UGC flow 'computer' that SBRG are purchasing for use with a couple of turbine flow meters used elsewhere. This would save the cost of the flow calculator portion of the Stauff unit (approximately US $1000.). However, the adaptability of the UGC unit to the 'polarized' bidirectional dual signal channel from the Stauff sensor head seemed questionable. Other arrangements	

DISCUSSIONS	ACTION
were also considered using a unidirectional sensor in an appropriate part of the hydraulic flow circuit and range switching the UGC unit to account for the difference in volume displacement on the rod end and the non-rod end of the hydraulic cylinder. In these, and other approaches attempting to use the UGC unit, it was felt that the potential risks of adapting the UGC unit were greater than the US $1000 savings gained by eliminating the Stauff flow calculator. Purchasing the Stauff sensor head and calculator as a 'matched pair' results in a proven workable system. DSMA are to query Stauff further on their accuracy claims to ensure that they apply to the totalized flow output signal as well and not just to the 'count' displayed on the Stauff unit. Actual volume displacements pertinent to the SBRG application are to be considered when reviewing accuracies.	DSMA
3. POSITION DISPLAY/TRIP UNIT A bar graph panel indicator complete with 3 adjustable position trip relays was reviewed—a Versatile Dixson Model 9051-31 meter relay manufactured by Versatile Measuring Instruments, Inc. of 55 Six Point Road in Toronto. It appears quite suitable and costs less than purchasing and assembling individual position monitoring relays and a separate panel indicator. A 1% resolution unit is available at $680.00 (Canadian $'s, FOB Toronto). DSMA are to review the compatability of this display unit with the bipolar signal inputted from the Stauff flow totalizer. If compatability is a problem, Stauff are to be consulted regarding the possibility of having their unit output an unidirection signal covering the full bidirectional flow range (e.g. a 0 to +10 VDC output signal indicative of maximum negative flow to maximum positive flow).	
4. PLC The G-E Series One PLC has been selected as the most appropriate for the scraper position controller. All logic, timing and operator interface functions will be incorporated in it. SBRG will define the hardware requirements based on DSMA's control logic sketches.	SBRG

DISCUSSIONS	ACTION

5. CONTROL LOGIC

DSMA presented 2 sketches (Sketch 84-08-23-1 and -2) and a preliminary "Scraper Control System" description as a starting point for discussion. Discussions/conclusions included the following:

i) The concerns of leakages in the hydraulic flow circuit that could result in errors in the implied scraper position as measured by the flow sensor are important if the high and low position trip points are set very near the travel extremities. If all of the piston movement does not register as flow through the flow sensor for some reason, then the scraper may bottom or top out against end stops before the corresponding position relay is tripped.

This is not a problem in the case of the DOWN cycle in the 'AUTO CYCLE' mode, as there is a continuing flow of fluid through the flow sensor during the bottom dwell time, as 'cooling flow' passes through the piston's self-contained relief valve. If the bottom position trip relay is not tripped before the scraper bottoms out, this subsequent flow of 'coolant fluid' will trip the position relay shortly thereafter. However, no equivalent 'relief' flow is available at the top of the scraper's stroke.

It was decided that a pressure relief valve should be added to the hydraulic circuit to pass a 'relief flow' of fluid through the circuit if the hydraulic directional flow control valve was maintained in the UP position after the scraper has topped out. This would insure that the high position trip relay will be actuated, even if set at or very near the top.

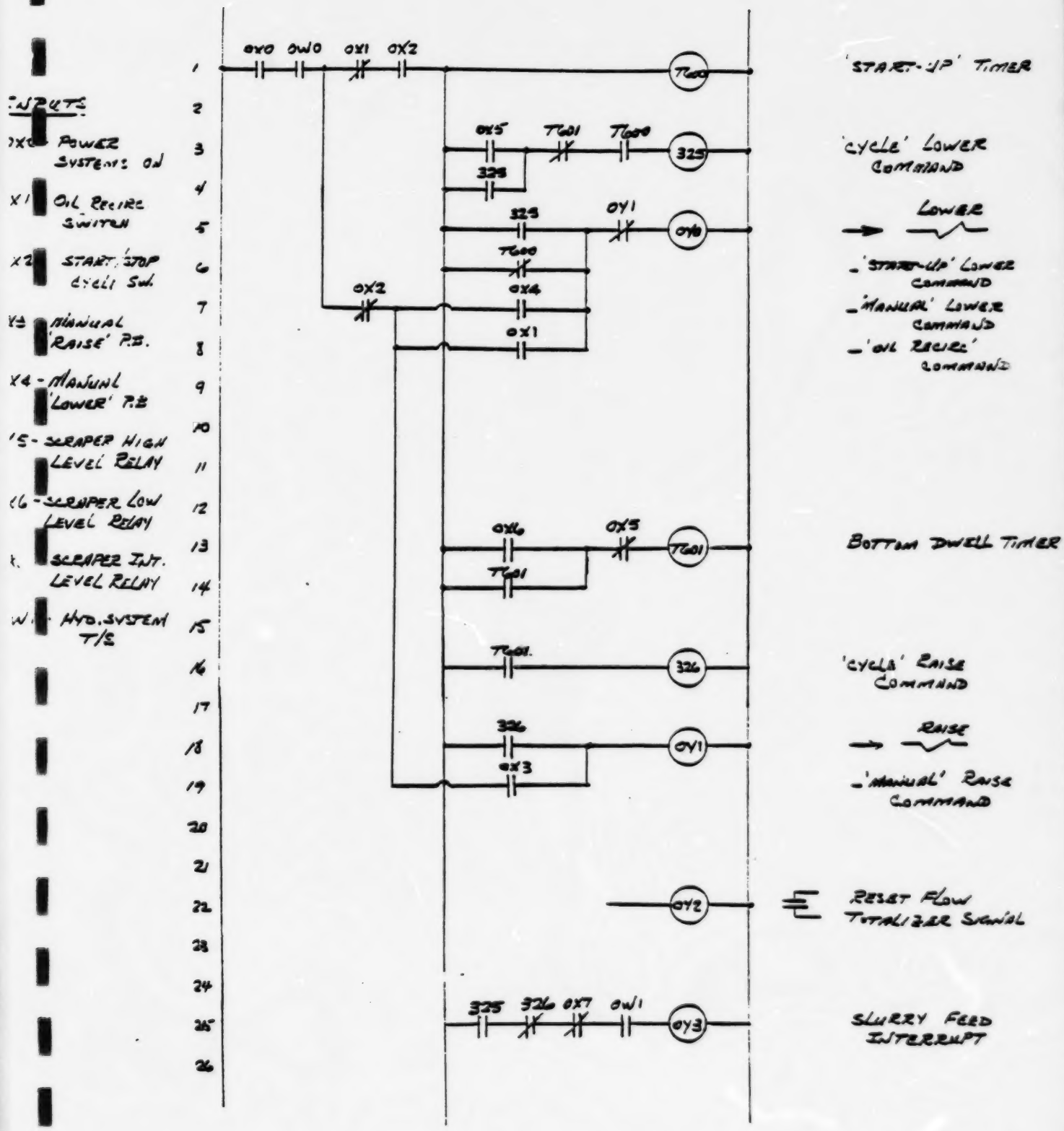
ii) Two 'diagnostic' timers are to be added to the PLC logic, one for each of the UP and DOWN stroke cycles. These would be set at longer times than required for the corresponding strokes and would be reset by the corresponding high or low position trip relays. Under normal operation, these would never time out. However, if the cycle hung up, the corresponding UP of DOWN diagnostic timer would time out and actuate an alarm indicating light on the Operator's Control Station.

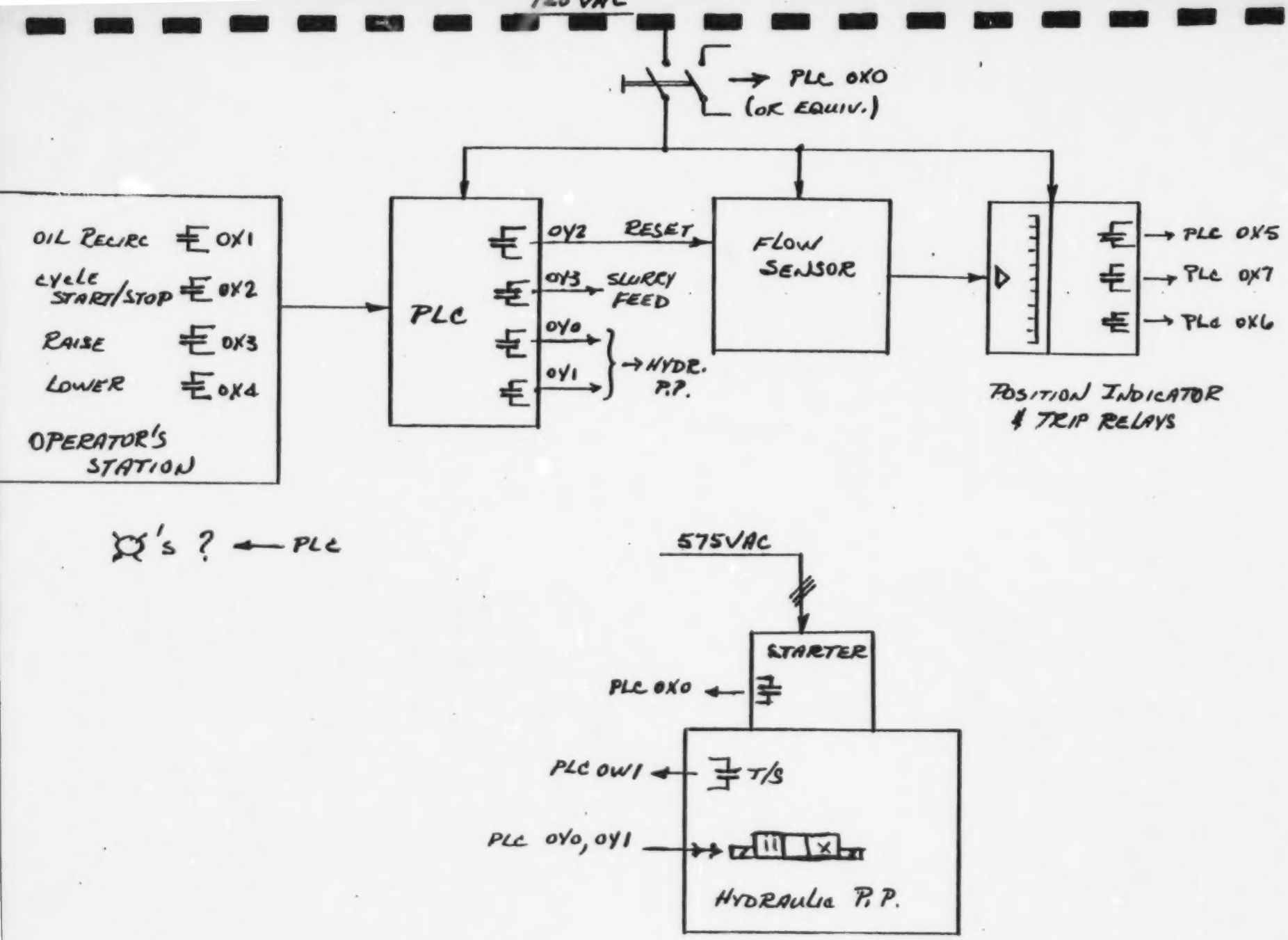
A reset pushbutton must also be added to reset the 2 timers.

DISCUSSIONS	ACTION
iii) High oil temperature in the hydraulic circuit shall not interrupt the slurry feed. SBRG are considering the use of continuous temperature indications at each of the hydraulic cylinder's inlet/outlet port connections. SBRG will select appropriate sensors, indicators and alarm equipment to suit.	SBRG
DSMA shall specify appropriate accommodations in the piping connections to the hydraulic cylinder for installation of these temperature sensors, if they are internal hydraulic fluid sensors. SBRG must inform DSMA of requirements in this regard. If surface-mounted sensors are attached to the outside of the hydraulic piping, no special mounting provisions will be required.	DSMA
Temperature alarms will drive warning lights directly. There is not need to put them through the PLC.	
6. DOCUMENTATION/EQUIPMENT SPECIFICATION	
SBRG stated that sketches similar to those left at the meeting will be sufficient for them to work from. No formal drawings are required. Bills of Material shall be provided for major equipment (e.g. flow sensor, position indicator and relay unit). SBRG will select all 'routine' equipment including panel switches indicating lights, etc. and all power supply equipment.	DSMA/SBRG
A motor starter shall be supplied with the hydraulic power pack for the pump motor. Start/stop of the hydraulic power pack shall be via the PLC (per Aug. 27th Telecon with L. Howarth of SBRG).	

SCRAPER POSITION CONTROL SYSTEM

PRELIMINARY





SKETCH 84-08-23-2 SCRAPER CONTROL SYSTEM EQUIPMENT – OVERVIEW

SCRAPER CONTROL SYSTEM (PRELIMINARY)

The scraper position throughout its stroke range is inferred from the hydraulic fluid displacement in the actuating cylinder. This is measured by a positive displacement, bi-directional sensor/totalizer in the supply/return line to the piston end of the cylinder. Since small leakages may occur across the piston, the totalized flow signal will be reset to zero every time the piston is stroked to its bottom position (against the end stop). This will ensure that there will be no error accumulation in the scraper position reading inferred from the fluid flow measurement. The only position error attributed to cylinder leakage will be for one actuator cycle only, and this should be quite small.

The starting cycle initally forces the piston to its bottom position and resets the flow signal to zero. The first UP-stroke then starts immediately. Co-incident with the "RAISE" command, the slurry feed interrupt is actuated. The speed of the UP-stroke is adjusted by a hydraulic flow control valve. A panel meter displays the scraper position, and it is equipped with 3 adjustable position trip relays—a high, low and intermediate trip. The scraper continues its UP-stroke until it actuates the high trip relay. This immediately reverses the hydraulic directional control valve and starts the scraper DOWN-stroke with no delay at the top.

The scraper DOWN-stroke speed is adjusted by a second hydraulic flow control valve (independent of the UP-stroke speed). During the DOWN-stroke when the intermediate trip relay position is reached, the slurry feed interrupt is enabled again.

The scraper continues its DOWN-stroke, actuating the low position trip relay. This starts a 'dwell' timer which is set at the time desired for the scraper to dwell at the bottom of its stroke. Throughout this timed

period the hydraulic directional control valve is held in the "LOWER" position. The scraper will continue to the bottom stop and rest there during the dwell time. The subsequent pressure build-up in the hydraulic cylinder forces a 'cooling flow' of hydraulic oil through the relief valve contained within the cylinder's piston, back to the hydraulic power pack sump, thus permitting heat removal from the cylinder (resulting from the hot slurry feed) during this dwell period. At the end of the timed period, the UP-stroke cycle is started again.

The hydraulic flow sensor producing the inferred position signal will continue to meter the fluid cooling flow while the scraper is held against the bottom stop during the dwell period. Hence its signal will be clamped, or held at the reading existing when the low level trip point is actuated (presumably at or very near the bottom of the stroke), and will be reset to zero and released to monitor the UP-stroke position at the start of the UP-cycle.

In addition to the above AUTO cycle, when the AUTO cycle is turned off the scraper can be raised or lowered by depressing the 'RAISE' or 'LOWER' pushbuttons at the operator's control station. These pushbuttons are disabled when the AUTO cycle is turned on.

An oil recirculation mode is also provided. When selected during the AUTO mode, it immediately interrupts the AUTO cycle and energizes the hydraulic directional control valve with a 'LOWER' command. If the AUTO mode is still selected when the oil recirculation mode is shut off, the AUTO cycle will start from the beginning of the UP-cycle, assuming the low level dwell time has timed out. The flow meter signal will be clamped at the low trip point level (when it is reached) and will be released to normal control logic when the oil recirculation mode is switched off.

System interlocks are still to be finalized. Presumably, appropriate locations in the hydraulic circuit will have to be monitored for overheating, and in addition to shutting down the hydraulic power pack, the slurry feed should be stopped. Other permissive interlocks for operation of the scraper control system include the establishment of all supporting power supplies, including electrical and hydraulics.

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: DSMA International Inc.
10 Park Lawn Road
Toronto, Ontario
M8Y 3H8

DATE: August 28, 1984

PRESENT: P. Groeneweg - SBRG
P. Duggan - DSMA

DISTRIBUTION: S.L. Hodd - SBRG
P. Groeneweg - SBRG
C. Balkwill - DSMA
V. Silaghi - DSMA
P. Duggan - DSMA
File 4053/B1

DISCUSSIONS	ACTION
1. FABRICATION Contract for the centrifugal separator machined components has been awarded to Horn Industries and completion is anticipated by September 14. A meeting was held at Horn's to discuss machining tolerance requirements. Assembly and balancing of the components will be handled by Orenda. N.O.W. and Anderson Metals will quote on the fabrication of the containment vessel, when drawings are complete. 2. CONTAINMENT VESSEL SBRG requested several changes to the containment vessel design. The support stand height will be increased from 670 to 1500 mm, possibly by the introduction of a separate base stand. The slurry feed pipe will be altered to a vertical stand pipe arrangement. Dowels will be installed to guide the vessel lid and prevent interference of the deflector shield with the collector vessel. Blind flanges will be included for mixer connection and solids collection hopper. The solvent inlet pipe will be	

DISCUSSIONS	ACTION
altered to include two ducts with suitable eductors (3/8" pipe thread). This is to allow 6 seconds for the complete passage of solvent throughput.	
3. HYDRAULIC SYSTEM	
A preliminary hydraulic circuit diagram has been prepared for discussion. A pressure relief valve will be included to ensure that the flow counter can be zeroed if the cylinder piston bottoms early. An oil cooler will be included to eliminate overheating of the hydraulic oil caused by high process temperatures. Hoses to connect the hydraulic power pack with the rotary joint will be included in the supply of the power pack fabricator. SBRG to specify necessary hose length. DSMA to compile list of potential fabricators.	SBRG DSMA
Next meeting to be held August 30 at 1:30 p.m.	

MINUTES OF MEETING

PROJECT: DSMA Project 4053
Centrifugal Separating Machine

PLACE: DSMA International Inc.
10 Park Lawn Road
Toronto, Ontario
M8Y 3H8

DATE: August 31, 1984

PRESENT: P. Groeneweg - SBRG
P. Duggan - DSMA

DISTRIBUTION: S.L. Hodd - SBRG
P. Groeneweg - SBRG
C. Balkwill - DSMA
V. Silaghi - DSMA
P. Duggan - DSMA
File 4053/B1

DISCUSSIONS	ACTION
1. DRAWINGS Detail drawings of the centrifugal separator mechanical assembly have been completed and approved by DSMA. Four sets of approved prints were supplied to SBRG and it was agreed that five sets of 11" x 17" reduced prints will be supplied to SBRG by September 5. Work is progressing on the hydraulic schematic and completion is anticipated by September 5. DSMA will then contact potential suppliers of the hydraulic system for quotations.	DSMA DSMA
2. HYDRAULIC SYSTEM SBRG estimate hydraulic oil cooling requirements at 3 kw based on heat transfer calculations for the centrifugal separator. Heat exchanger design should be based on an inlet water temperature of 15°C through a 1/4" dia. supply line.	

DISCUSSIONS	ACTION
It was agreed that the power pack will terminate in self seal couplings and remaining equipment between the power pack and the rotary joints will be installed on the rear of the SBRG control panel.	
3. DRIVE MOTOR	
SBRG have received quotes for the main 71/2 HP drive motor with speed control but the output speed may be different to that originally specified requiring a change to the drive pulley size and the drive belt length. SBRG to advise details of this change.	SBRG
On receipt of technical information DSMA will check performance against acceleration/deceleration requirements.	DSMA

APPENDIX B

FABRICATION QUOTATIONS

Horn W.J. Industries Ltd.
MANUFACTURING CENTER
AIRCRAFT - NUCLEAR - MARINE COMPONENTS

1111 FINCH AVENUE, WEST,
UNIT 28, DOWNSVIEW, ONT.,
CANADA M3J 2E5
TEL. [illegible]

AUG 21 1984

TO: Sandwell Beak Research Group,
6870 Goreway Drive,
Mississauga, Ontario.

ATTN: _____ REF: Verbal Inquiry

QUOTE No.: № 000754
DATE: August 16, 1984
PAGE 1 OF 1
PHONE: 665-8113

ITEM	DESCRIPTION	QTY.	UNIT PRICE
	To Supply Material & Manufacture As Per Dwgs & Applicable Specifications		
1	Hydraulic Cylinder Details Dwg. # 4053-105 Details A,B,C,D,E,F,& G		$3,204.00 Lot
2	Cylinder Details Dwg. # 4053-106 Detail A,B,C,D,E,& F		$5,219.00 Lot
3	Separator Details Dwg. # 4053-107 Details A,B,C,D,E & F		$4,999.00 Lot
4	Housing Details Dwg.# 4053-108 Details		$9,485.00 Lot
5	Separator Details Dwg. # 4053-109 Details A,B,C,D,E,& F		$2,369.00 Lot
	Terms & Conditions A. Detail Parts Only (No Assy.) Material: 304 St.St. B. Testing Excluded C. Delivery: Sept. 14, 1984 D. F.O.B. Destination E. 12% Premium Payable On Total Cost To Meet Sept.14 Delivery	Total Cost Premium Total	$25,276.00 3.033.12 $28,309.12

F.O.B. _____
DELIVERY As Required
TERMS Net 30 Days
TAXES Extra
FIRM _____ DAYS

YOURS TRULY

HORN W.J. INDUSTRIES LTD.

• SPECIALISTS IN FINE QUALITY WORK

QUOTATION

PHONE (416) 738-0093
from Mississauga (416) 738-4611

131 SPINNAKER WAY, CONCORD, ONTARIO, CANADA L4K 2T2

INQUIRY

DATE Aug. 23/84

OUR QUOTATION № 013515

DATED

Sandwell Beck Research Group
6870 Goreway Drive
Mississauga, Ontario
L4V 1L9

Attention: Stephen Hodd

QUANTITY	DESCRIPTION	EXTENSION
	Dear Sir:	
	We are pleased to quote as follows:	
	Solvent Tank Weldment #4053-101 Solvent Tank Cover Details #4053-103 Centrifugal Support Frame #4053-111	$14,630.00/lc
	Delivery- 5-6 Weeks after Receipt of Order.	
	Drawings returned with quote.	

DUTY & TAXES EXTRA

TERMS: Net 30 days

DELIVERY: 5-6 weeks FOB.

ANDERSON METAL INDUSTRIES INC.

PER

N·O·W· & ASSOCIATES INC.
452 BOWES ROAD, P.O. BOX 240, CONCORD, ONTARIO L4K 1B4

Sandwell Beak Research Group
6870 Goreway dr.,
Mississauga, Ontario
L4V 1P1

August 22nd, 1984

Attn.: Dr. P.G. Groeneweg, Ph. D., P. Eng.
Director, Technology Development

Dear Sir;

REF.: CENTRIFUGE SEPARATOR
OUR QUOTE 3421/84

With reference to your visit of August 16 we are pleased to quote as follows:-

TO SUPPLY MATERIALS, FABRICATE AND MACHINE CENTRIFUGE DETAILS TO YOUR DRAWINGS E4053-101, 103 & 111

Assembly is not included

PRICE: $ 9,375.00 Lot

Delivery : 4 - 6 Weeks

TAXES : Extra if applicable

F.O.B. : Our Plant, Concord, Ontario

TERMS : 1% - 10 Days, Net 30 Days
2% per month on overdue accounts
24% per annum.

Your Drawings are returned as requested.

Yours very truly,
N.O.W. & ASSOCIATES INC.

A. Wilkins
Sales Manager

AW/mb

N·O·W· & ASSOCIATES INC.
452 BOWES ROAD, P.O. BOX 240, CONCORD, ONTARIO L4K 1B4

Sandwell Beak Research Group
6870 Goreway Dr.,
Mississauga, Ont
L4V 1P1

September 5th, 1984

ATTN.: DR. P.G. GROENEWEG, PH. D., - P. ENG.
DIRECTOR, TECHNOLOGY DEVELOPMENT

Dear Sir;

REF.: CENTRIFUGE SEPARATOR
OUR QUOTE 3421/84

With reference to your visit of August 16 we are pleased to quote as follows:-

TO SUPPLY MATERIALS, FABRICATE AND MACHINE CENTRIFUGE DETAILS TO YOUR DRAWINGS E4053-101, 103, 104 and 111

Fabricated Tolerance on Angles is $\pm 2^{0}$

Assembly is not included.

PRICE: $ 11,500.00 Lot

DELIVERY : 3 - 5 Weeks as requested.

TAXES : Extra if applicable.

F.O.B. : Our Plant, Concord, Ontario.

TERMS : 1% - 10 Days, Net 30 Days
2% per month on overdue accounts
24% per annum.

Trusting the above meets with your approval, we remain,

Yours very truly,
N.O.W. & ASSOCIATES INC.,

A. Wilkins
Sales Manager

AW/mb

QUOTATION

September 24, 1984
Quotation #4299

DSMA International Inc.
10 Park Lawn Road
Toronto, Ontario
M8Y 3H8

Attention: Philip Duggan, P. Eng.

Dear Philip:

We are pleased to quote the following on our quotation #4299 as follows:

One (1) only power unit as per your drawing number 4053-112, with 5 H.P. Motor coupled to a PV6 Denison pump. The complete system will be assembled, painted and tested. The cylinder relief valve, gauges, snubbers, flow control and check will be included as loose items.

NET PRICE $4350.00

Please Note: The starter is not included in this quote.

I trust the afore description is what one requires and I look forward to hearing from you in the near future. Please do not hesitate to contact me if you require any further information or assistance.

Delivery: T.B.A.
Valid : Quote valid 45 days
Terms : Net 30 days
F.O.B. : Our plant, Downsview, Ontario
Extra : Taxes & Duty extra if applicable.

Check 2es.

John F. McIntyre
Sales Representative

JM:th

EASTERN HYDRAULICS LIMITED
425 NORFINCH DRIVE
DOWNSVIEW, ONTARIO
M3N 1Y7
(416) 663-9472
Telex 065-27123

SEP 13 1984

hydraulics by Frontier

Frontier Hydraulics Ltd.

2260 B Industrial Street
Burlington, Ont. L7P 1A1
Telephone: (416) 335-1171
Telex: 061-8213

QUOTATION

SHEET 1 OF 1

TO D.S.M.A.
ATT'N Mr. Phil Duggar
10 Parklawn Road
TORONTO, Ontario

RE: Hydraulic Power Pack

QUOTATION NUMBER	105684
DATE	September 11, 1984
TERMS	Net 30 days
TAXES	Excluded
FOB	Burlington
DELIVERY	T.B.A.

IN RESPONSE TO YOUR INQUIRY WE SUBMIT THE FOLLOWING QUOTATION

QUANTITY	DESCRIPTION	UNIT PRICE
1	T20-20 Gallon Hydraulic Power Pack per your drawing 4053-112 assembled and piped. Excluding the hydraulic cylinder, shut off flow sensor, and thermocouples. Includes wiring of starter to electric motor. Please Note: This is only a confirmation of our original quote sent to you via telex on September 11, 1984.	$ 5,049.00 Net

OTHER INFORMATION

BY Lyle Zeran

PRICES SUBJECT TO REVIEW AFTER 30 DAYS

PLEASE REFER TO THE ABOVE QUOTATION NUMBER ON ALL CORRESPONDENCE

Lyle Zeran.

Service that Satisfies

[redacted] fluid power ltd.

379 Limestone Crescent
Downsview, Ontario M3J 2R1
Tel: (416) 661-0130

5430 Van Den Abeele
Montreal, Quebec H4S 1P9
Tel: (514) 337-8133

QUOTATION
SOUMISSION

NUMBER/NUMERO
1302/03

Please refer to this QUOTATION when corresponding or ordering.
Veuillez referer a ce no. pour fin de correspondance.

DATE September 7, 1984

YOUR INQUIRY/VOTRE DEMANDE

TO/ATTN: SANDWELL BEAK RESEARCH GROUP
C/O DSMA INTER. INC.
10 Park Lawn Road
Toronto, Ont.
M8Y 3H8

FROM/DE
Greg Straumann
Technical Sales Representative

ATTN./A/S Mr. Phillip Duggan, P. Eng.

ITEM ITEM	QUANTITY QUANTITE	DESCRIPTION / DESCRIPTION	PRICE PRIX	DISCOUNTS ESCOMPTE
		We are pleased to present this quotation for your consideration:		
		QUOTATION 1302 ==========		
	1	HYDRAULIC POWER PACK AS PER YOUR DRAWING 4053-112 C/W 20 U.S. GALLON RESERVOIR, 5 HP @ 1,800 R.P.M. ELECTRIC MOTOR, TEMPERATURE SWITCH AND RELOCATED HEAT EXCHANGER AS SHOWN ON MARKED UP DRAWING. APPROX. RESERVOIR DIMENSIONS 685 L X 600 W X 700 H.		
		COMPLETE PRICE OF UNIT TESTED & PAINTED	$ 4232.39	N E T
		DELIVERY: 6 - 8 WEEKS		
		QUOTATION 1303 LOOSE ITEMS AS PER YOUR ========== DRAWING 4053-112 C/W 5 HP STARTER UNIT A & B. 575/3/60 REMOTE, OFF, LOCAL SWITCH, RED RUNNING LIGHT, TRANSFORMER AND FUSE TYPE STARTER PART #512AAC2434R-6.		
		LOT PRICE	$758.70	N E T
		Thank you for this opportunity to quote on your requirements.		

F.O.B./F.A.B. DOWNSVIEW, ONT.

PRICES FIRM FOR 30 DAYS/PRIX FERME - 30 JOURS

TERMS/TERMES NET THIRTY DAYS

TAXES: EXTRA WHERE APPLICABLE/TAXES EN SURPLUS SI APPLICABLES

NOTE: Warranty and other conditions of sale are set forth on the back of this form, or attached form.
NOTE: Voir au verso, ou feuille attache pour conditions de vente et guarantie.

Thank you for this opportunity to quote. Please call on us if you need further information or assistance.
Nous vous remercions de votre attention. Si plus amples informations sont requise veuillez nous contacter.

By/Par _____

[illegible]

D.S.M.A.
10 Parklawn Rd.,
TORONTO, Ontario.
M8Y 3H8

Attention: Mr. Phil Duggan

QUOTATION 1130

September 14, 1984.

We are pleased to submit our quotation as follows:

QUANTITY	PART NO	DESCRIPTION	EACH NET
1 Only		N.H. Hydraulic Power Unit consisting of 20 U.S. gallon reservoir c/w filler breather and level indicator, suction strainer, variable volume piston pump (PV85), 5 HP @ 1800 RPM 184 TC ODP 575/3/60 electric motor, c/w starter, bell housing, coupling, 10 micron high pressure filter, 25 micron high pressure filter, inline check valve, 1 gallon accumulator c/w shut-off valve, inline shut-off valve, return filter, inline relief valve, gauge c/w shut-off valve, directional control valve, module dual flow control valve and mounting bolt kit. Power unit to be assembled, piped, tested and painted.	
		LOOSE ITEMS	$ 4,364.84
2 Only	PGL25-2000S	Gauges	$ 22.10
3 Only	MV400	Shut-off valve	$ 24.00
2 Only	FD45-1000-06-06	Self-seal coupling	$ 16.50
1 Only	6101-1	Inline relief valve	$ 54.95

Trusting the above meets with your approval and if you require any further information please do not hesitate to call.

Yours truly,
NATIONAL HYDRAULICS CO. LTD.

Dieter Schuhmann, C.E.T.

Crating
Concord, Ont. Extra
Extra, if applicable
Extra, if applicable
As per agreed schedul

VICKERS SYS. INC.

280 ATTWELL DRIVE
REXDALE, ONTARIO M9W 5B6
(416) 675-7780

4155 McCONNELL DRIVE
BURNABY, B.C. V5A 3J7
(604) 421-1755

1159 AUTOROUTE #440
LAVAL, QUEBEC H7L 3W3
(514) 663-6780

100 WRIGHT AVENUE, SUITE 3
DARTMOUTH, N.S. B3B 1L2
(902) 469-0535

OCT 9 1984

DSMA International Inc.
10 Parklawn Rd.
Toronto, Ontario
M8Y 3H8

IN REPLY PLEASE REFER TO
AU MOMENT DE RÉPONDRE, PRIÈRE DE MENTIONNER
À

27A-094-23-45

September 26, 1984

Attention / À l'attention de: Mr. Phillip Duggan

Subject / Objet: 20 U.S. Gallon Power Pack

Gentlemen / Messieurs: (Project #4053)

We are pleased to quote on the following, subject to the terms and conditions on the reverse side of this sheet.
Il nous fait plaisir de vous présenter cette soumission, sous réserve des termes et conditions stipulés au verso.

ITEM	QTY.	DESCRIPTION	PRICE EACH
1	1	T20 - 20 U.S. Gallon Power Pack in general to your schematic 4053-112 issue September 7, 1984, incorporating the following components:	

1) 20 U.S. Gallon Reservoir, c/w Level Gauge and Filler Breather
1) OF3-08-10 Inlet Strainer
1) PVB5 Piston Pump
1) 5 H.P. at 1800 R.P.M., 575/3/60 TEFC Frame 184TC Electric Motor
1) OFRS-15-P-PA-10 Return Filter
1) ABT-03-10 Air Bleed Valve
1) GM-3000-20 Pressure Gauge and Snubber
1) A/B Motor Starter, bulletin 709-AGD, NEMA 4 with local and auto stop/start, wired to 5 H.P. Electric Motor.
1) DG4V-3-2C-WB-12 Directional Control
1) DGMFN-3Y-A2W-B2W-20 Flow Control Module
1) DGMC3-PT-CW-20 Relief Module
1) DTNG2-02-PM-10 1/4" NPT Needle Valve

cont'd....

VICKERS S.Y.S. INC.

Quote No. 27A-094-23-45 -2- September 26, 1984
Attn: Mr. Phillip Duggan

ITEM	QTY.	DESCRIPTION	PRICE EACH
1	Cont'd....		
		1) A1-200-20 Accumulator	
		1) FN-03-20 Accumulator Flow Control	
		2) Pressure Filters 10 & 25 micron	
		1) A/B NEMA 4 Temperature Switch completely wired to motor starter	
		2) 3/8 Quick Disconnects (Male Half)	
		1) OCW-2B-10 Oil/Water Cooler	
		All completely assembled, piped, tested and painted Vickers Blue in accordance with Vickers S.Y.S. Inc. standard specifications. (Est. 1331).	$5,982.00 Net

LOOSE COMPONENTS

2	2	GP-3000-20 Pressure Gauge 2 1/2" dia.	$ 61.00 -37%
3	2	DTNAS3-02-PM-10 Needle Valve	$ 30.00 -37%
4	1	CT-06-C-50 Relief Valve	$ 176.00 -37%
5	1	DTNG2-04-PM-10 1/2 NPT Needle Valve	$ 53.00 -37%

Prices are for articles quoted only. Additional services requested by the buyer or user will be subject to charges according to the attached schedule.

Federal and Provincial taxes, extra, if applicable.

F.O.B. our plant in Rexdale, Ontario.

Delivery: 10 to 12 weeks from receipt of your order, subject to confirmation at time of receipt of your order.

Yours very truly,

VICKERS S.Y.S. INC.

Brian Makins

Brian Makins
Technical Sales Representative

BM/dlp
Attach.